CHEMISTRY LETTERS, pp. 977-980, 1980.

REACTIONS OF SILYL-SUBSTITUTED CARBANIONS WITH NITRONES

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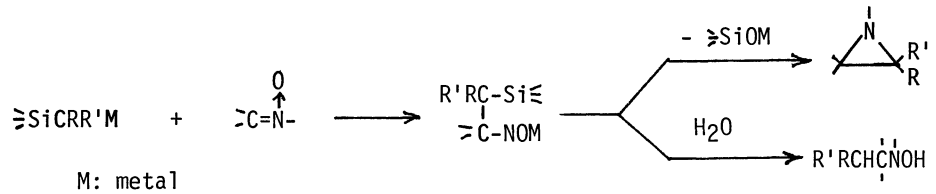
The reaction of carbanions, prepared from 2-(trimethylsilylmethyl)pyridine or N,N-dimethyltrimethylsilylacetamide and lithium diisopropylamide in tetrahydrofuran, with α-aryl-N-phenylnitrones afforded a mixture of the corresponding (E)-alkene, azobenzene and azoxybenzene, respectively. On the other hand, the carbanions reacted with cyclic nitrones to give the corresponding aziridine and/or hydroxylamine derivatives as major products.

Several kinds of reactions using silyl-substituted carbanions have recently been developed. In particular an important application of silyl-substituted carbanions is in the conversion of carbonyl compounds to the corresponding alkenes (the Peterson reaction).[1-7] It has also been found that lithio 2-(trimethylsilylmethyl)pyridine reacted with Schiff bases to give 2-(alkenyl)pyridines.[8] Upon consideration of the above olefination reactions, it seemed that the conversion of nitrones to aziridines and/or hydroxylamines could be effected using silyl-substituted carbanions as illustrated below.



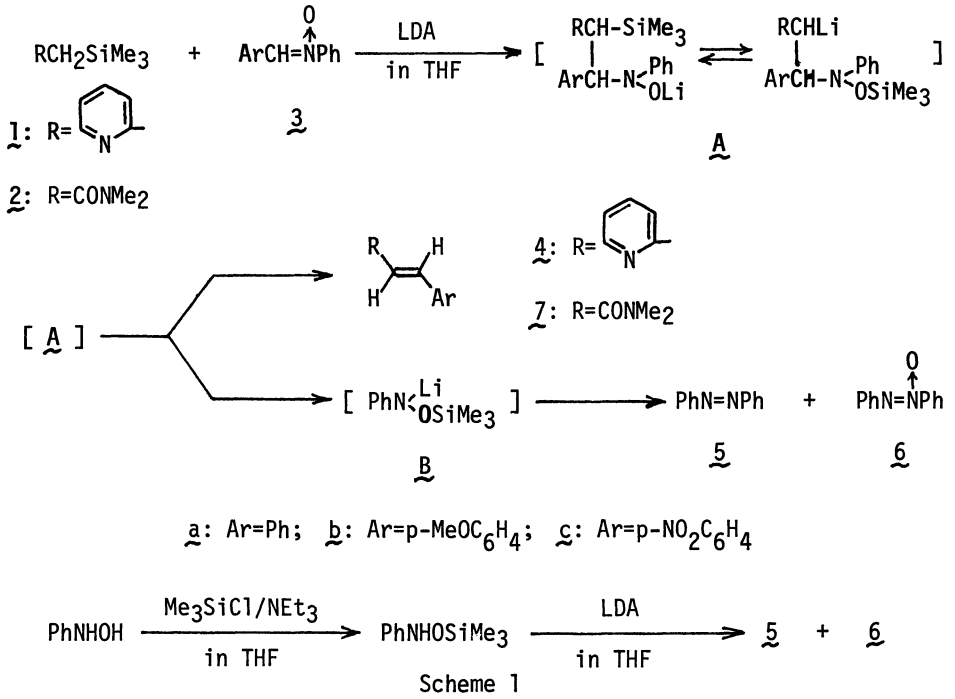
However, the reaction of silyl-substituted carbanions with nitrones has not so far been investigated. We now wish to report the reactions of carbanions, prepared from 2-(trimethylsilylmethyl)-pyridine (1)[9] or N,N-dimethyltrimethylsilylacetamide (2)[10] and lithium diisopropylamide (LDA) in tetrahydrofuran (THF), with α-aryl-N-phenylnitrones and cyclic nitrones.

Contrary to expectation, lithio derivative of 1 reacted with α-aryl-N-phenylnitrones (3) to give a mixture of the corresponding (E)-1-aryl-2-(2-pyridyl)ethene (4), azobenzene (5) and azoxybenzene (6) (Scheme 1).

A general procedure is illustrated as follows. A solution of 3 (10 mmol) in THF[11] was added, drop by drop, to a solution of lithio derivative of 1 in THF, which had been prepared at -75°C by treatment of 1 (10 mmol) with LDA (10 mmol) in THF (18 ml) according to the reported procedure[7]. After the resultant mixture was stirred at -75°C for 1 h, it was allowed to warm to room temperature during 1 h, and then stirred at this temperature for 2 h. The reaction mixture was quenched with water and extracted with ether. The ether extract was dried and evaporated in vacuo, and the residue was triturated with hexane to give alkene 4. The hexane filtrate was evaporated in vacuo, and the residue was chromatographed on silica gel using hexane and benzene as eluents to give azobenzene (5), azoxybenzene (6), and 4, respectively.

Similarly, the reaction of lithio derivative of 2 with nitrones 4 afforded the corresponding (E)-alkenes 7, besides 5 and 6. Structural elucidation of products was accomplished on the basis of

spectral data. The results are summarized in Table 1.



Scheme 1

The pathway for the formation of alkene 4 or 7, azobenzene (5) and azoxybenzene (6) is outlined in Scheme 1. The lithio derivative of 1 or 2 reacts with 3 to yield A, which is dissociated into alkene 4 or 7 and B. The compounds 5 and 6 are derived from B, because treatment of N-trimethylsilyloxyaniline, prepared from phenylhydroxylamine and trimethylchlorosilane in the presence of triethylamine, with LDA in THF afforded 5 and 6 in 33 and 27% yields respectively. However, the reaction mechanism is not clear.

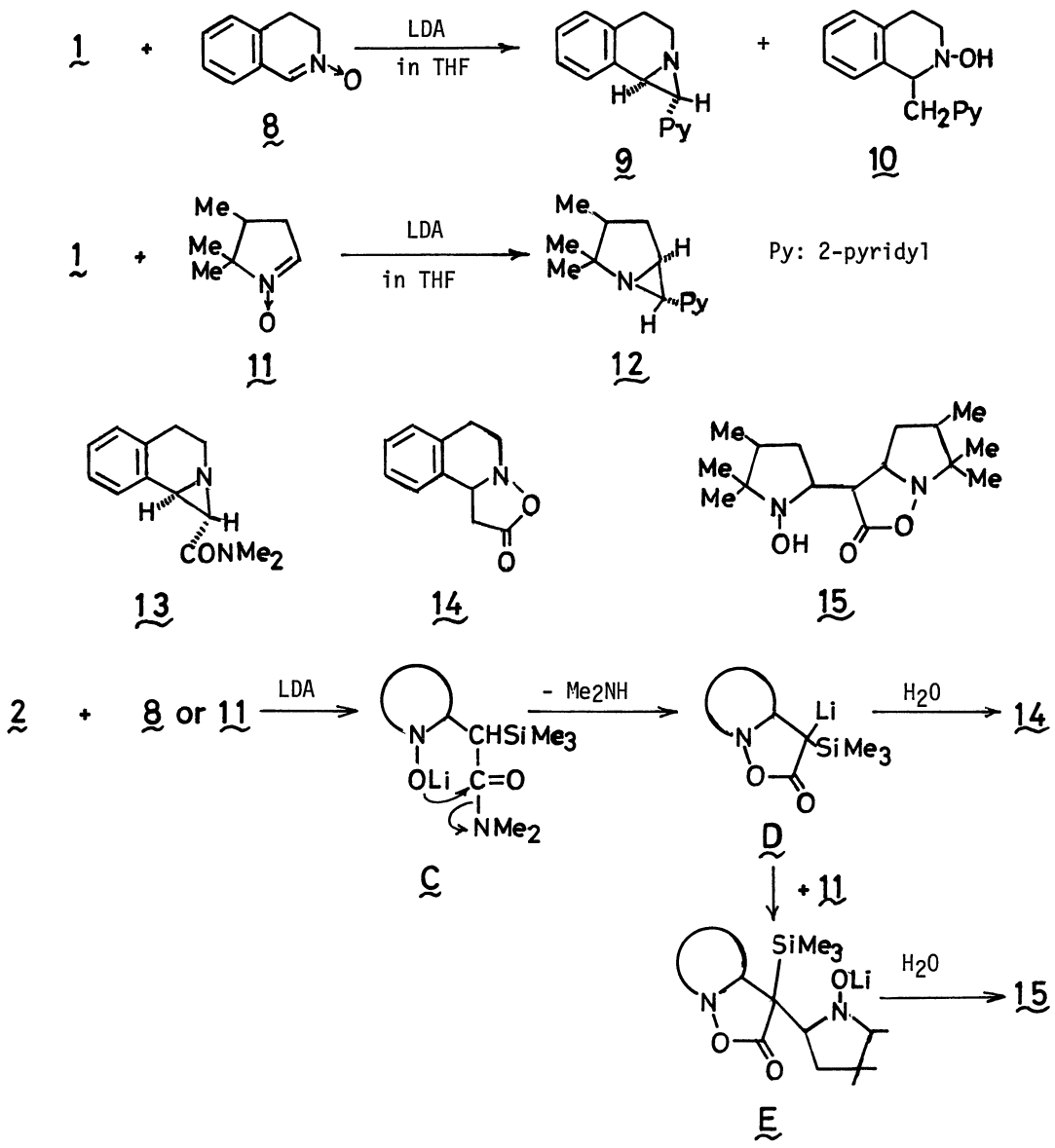
Table 1. Reactions of Lithio Derivatives of 1 and 2 with Nitrones 3

Nitrone	$RCHSiMe_3Li$ R	Product[a] (E)-Alkene R	Ar	Yield, %	Mp., °C	NMR, δ (Hz) =CH[b]	Yield, % 5	6
3a	2-pyridyl	4a 2-pyridyl	Ph	72	90-90.5[c]	7.19, 7.70 (17)	30	20
3b	2-pyridyl	4b 2-pyridyl	p-$MeOC_6H_4$	80	75.5-77	7.06, 7.63 (16)	19	47
3c	2-pyridyl	4c 2-pyridyl	p-$NO_2C_6H_4$	22.5	135-137.5	7.26, 7.69 (17)	18.5	12.5
3a	$CONMe_2$	7a $CONMe_2$	Ph	39	96-98	6.91, 7.71 (16)	—	31
3b	$CONMe_2$	7b $CONMe_2$	p-$MeOC_6H_4$	60.5	101-102	6.79, 7.68 (16)	11	57
3c	$CONMe_2$	7c $CONMe_2$	p-$NO_2C_6H_4$	20	176-178	7.09, 7.73 (17)	10	15

[a]In the reactions of 1 with 3c, and of 2 with 3a-3c, the corresponding nitrones 3 were recovered. [b]Measured in $CDCl_3$. Signals appear as doublets. [c]Reported mp: 90.5-91°C (C. Piechucki, Synthesis, 1974, 869).

Next, our attention was directed toward the reaction of lithio derivatives of 1 and 2 with cyclic nitrones; the reaction procedure was similar to that in the reaction with 3.

The reaction of lithio derivative of 1 with 3,4-dihydroisoquinoline N-oxide (8) afforded the expected aziridine 9 and hydroxylamine derivative 10 in 36 and 16% yields respectively, together with intractable materials. Similarly, the corresponding aziridine derivative 12 was isolated in 30% yield in the reaction with 4,5,5-trimethyl-1-pyrroline 1-oxide (11). Structural elucidation of 9, 10, and 12 was accomplished on the basis of spectral data. It can also be concluded that the two hydrogen atoms in aziridine rings of 9 and 12 are located at trans positions on the basis of coupling constants in the NMR spectra.[12]



Scheme 2

9: mp 85-86°C; NMR ($CDCl_3$) δ 2.48-3.16 (3H, m), 3.22, 3.35 (each 1H, d, J=2.3 Hz), 3.40-3.74 (1H, m), 6.92-7.37 (6H, m), 7.48-7.72, 8.40-8.56 (each 1H, m); MS m/e 222 (M^+).

10: mp 190-192°C; IR (KBr) 3250 cm^{-1} (OH); NMR (DMSO-d_6) δ 2.60-3.02 (4H, m), 3.47 (1H, t, J=7.0 Hz), 4.60 (2H, d, J=7.0 Hz), 6.88-7.28 (6H, m), 7.40-7.61, 8.15-8.35 (each 1H, m), 8.27 (1H, s, OH, exchanged with D_2O); MS m/e 240 (M^+).

12: mp 50-53°C; NMR ($CDCl_3$) δ 0.90 (3H, d, J=6.0 Hz), 1.08, 1.20 (each 3H, s), 1.56-1.82 (2H, m),

2.20-2.37 (1H, m), 2.49 (1H, dd, J=2.5, 4.0 Hz), 2.84 (1H, d, J=2.5 Hz), 6.96-7.24 (2H, m), 7.44-7.67, 8.36-8.52 (each 1H, m); MS m/e 202 (M^+).

On the other hand, the reaction of lithio derivative of 2 with 8 and 11 afforded different types of products. The reaction of lithio derivative of 2 with 8 afforded aziridine 13 and isoxazolidinone derivative 14 in 11 and 9% yields respectively, together with unidentified compounds. However, the reaction with 11 gave a 12% yield of 2-(1-hydroxypyrrolidinyl)perhydropyrroisoxazolidinone 15 as a sole isolable product.

13: mp 93-94°C; NMR ($CDCl_3$) δ 2.88-3.04 (2H, m), 2.98, 3.08 (each 3H, s), 3.31 (1H, d, J=2.5 Hz), 3.38-3.64 (1H, m), 6.96-7.44 (4H, m); MS m/e 216 (M^+).

14: colorless oil; IR (neat) 1775 cm^{-1}; NMR ($CDCl_3$) δ 2.60-3.76 (4H, m), 3.15 (2H, d, J=7.0 Hz), 5.04 (1H, t, J=7.0 Hz), 6.88-7.32 (4H, m).

15: mp 116-117°C; IR (KBr) 3300 (OH), 1760 cm^{-1} (C=O); NMR ($CDCl_3$) δ 0.84, 0.92, 1.08, 1.32 (each 3H, s), 0.88, 0.93 (each 3H, d, J=10.0 Hz), 1.44-2.50 (6H, m), 2.86 (1H, dd, J=1.0, 2.6 Hz), 3.26 (1H, ddd, J=2.6, 4.0, 9.2 Hz), 4.08 (1H, ddd, J=1.0, 5.9, 8.0 Hz), 6.43 (1H, broad); MS m/e 296 (M^+).[13]

The pathways for the formation of 14 and 15 are illustrated in Scheme 2. The reaction of lithio derivative of 2 with 8 or 11 leads to the formation of initial adduct C, which is transformed into D with the elimination of dimethylamine. The quenching of D with water gives 14, whereas D reacts with nitrone 11 to give 15 through E. Extensive studies on the reactions of silyl-substituted carbanions with variety of nitrones are in progress.

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11) Nitrones 3a, 3b, and 3c were dissolved in 12, 40, and 80 ml of THF, respectively.
12) Couplings of J_{cis} 5-6 Hz and J_{trans} 2-2.7 Hz were found for a large range of 3-substituted 1,2-diphenylaziridines (J. A. Deyrup and R. B. Greenwald, J. Am. Chem. Soc., 87, 4538 (1965)).
13) ^{13}C NMR of 15 ($CDCl_3$): δ 12.1, 13.8, 14.5, 19.6, 22.5, 25.1 (each q, $\underline{C}H_3$), 32.3 (t, $\underline{C}H_2$), 37.8, 39.7 (each d, $\underline{C}H$), 39.9 (t, $\underline{C}H_2$), 55.7, 64.8 (each d, $\underline{C}H$), 66.0 (s, quat. $\underline{C}$), 66.9 (d, $\underline{C}H$), 71.9 (s, quat. $\underline{C}$), 175.8 (s, $\underline{C}$=O). All new compounds in this paper gave satisfactory elemental analyses.

(Received June 10, 1980)