CHEMISTRY LETTERS, pp. 835-838, 1977. Published by the Chemical Society of Japan

SELECTIVE ALKYLATION AND DESELENENYLATION OF CYANOMETHYL PHENYL SELENIDE IN AQUEOUS MEDIUM, AND AN APPLICATION TO 1-CYANOCYCLOPROPENE SYNTHESIS

Yoshiro MASUYAMA, Yoshio UENO, and Makoto OKAWARA
Research Laboratory of Resources Utilization,
Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152

The alkylation followed by the deselenenylation of cyanomethyl phenyl selenide (1) gave α,β-unsaturated nitriles. The method was applied to generate 1-cyanocyclopropene, which was trapped using anthracene.

Recent progress in organic synthesis via selenium compounds has disclosed novel procedures for the synthesis of various olefins.[1] In most cases, however, the experimental procedures require very strictly anhydrous conditions and low temperature (-78°C) for the generation of carbanions.

On the other hand, organic synthesis including C-C bond formation in aqueous medium is one of the attractive subjects. However, the system in aqueous medium places many restrictions on the C-C bond formation and the transformation into other functionalities, since 1) limited active methylene compounds, which afford the stable carbanions in aq. alkali, have been employed in this system, and 2) the conversion of activating groups such as acyl, ester, and cyano in usual active methylene compounds to other functional groups is rather difficult.[2]

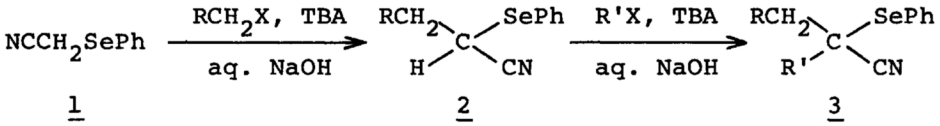
Considering the above problems in mind, we have investigated the possibility of new reagents in aqueous medium which might meet the following requirements;

1) alkylation and functionalization in aqueous medium,
2) protecting and activating groups for effecting time-controlled selectivity in the mono- and di-alkylation,
3) the facile conversion of protecting and activating groups into other functional groups.

We have previously reported the convenient synthesis of ketones from α-cyanomethyl dithioesters.[3] Considering the use of phenylselenenyl group as a leaving group, we wish to report here the utility of cyanomethyl phenyl selenide (1)[4] as a new reagent for α,β-unsaturated nitrile synthesis.

(a) Alkylation procedure.

Treatment of α-cyanomethyl selenide (1)[4] with alkyl halides (1.0 equiv.) in the presence of catalytic amount of $n\text{-}Bu_4N^+I^-$ (TBA) in aq. NaOH at room temperature for 3~10 hr gave monoalkylated products (2)[5] in high yields. Even by using double the molar quantity of alkyl halides, only monoalkylated products were isolated under these conditions. Dialkylated products (3)[5] were obtained in high yields by stirring for 7~20 hr under the similar conditions (Table 1).

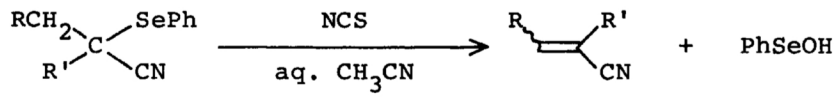


1 2 3

These results clearly demonstrate the reaction-time controlled selectivity in the alkylation of 1. The combination of cyano and phenylselenenyl groups presumably serves for effecting suitable stability and activity of the carbanion derived from 1, towards alkylation.

(b) Deselenenylation procedure.

Elimination of phenylselenenyl group was easily performed by the oxidation of 2 or 3 with N-chlorosuccinimide (NCS) or N-bromosuccinimide (NBS) (2.2 equiv.) in 60% aq. acetonitrile at room temperature for 3 hr to give the corresponding α,β-unsaturated nitriles (4)[5] in high yields (Table 1).



2 or 3 4

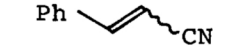
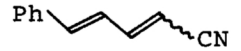
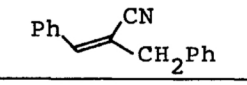
In addition, on treatment of 2 or 3 with 35% aq. H_2O_2 (10 equiv.)[1] for 2 hr at room temperature in tetrahydrofuran, the corresponding α,β-unsaturated nitriles (4)[5] were obtained in high yields (Table 1).

For the application of α,β-unsaturated nitrile synthesis, we investigated a new synthesis of 1-cyanocyclopropene.[6]

On treatment of 1 with 1,2-dibromoethane (1.0 equiv.) for 8 hr under the

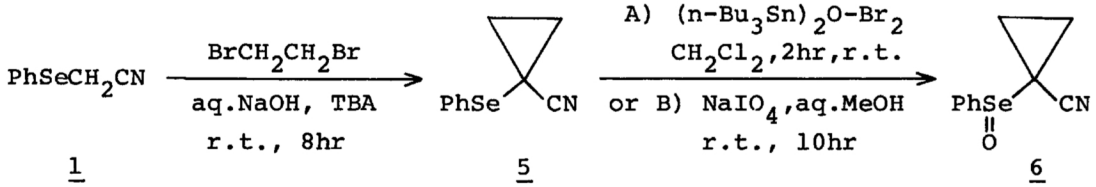
similar conditions as above, cyclopropyl selenide (5)[5] was obtained as an oil in 80% yield, IR; $\nu_{C\equiv N}$ 2260 cm^{-1}, NMR(CCl_4); δ=1.07~1.73 (4H, m), 7.10~7.43 (3H, m), 7.43~7.70 (2H, m), without any undesirable by-products.

Table 1. Alkylation and Deselenenylation[5]

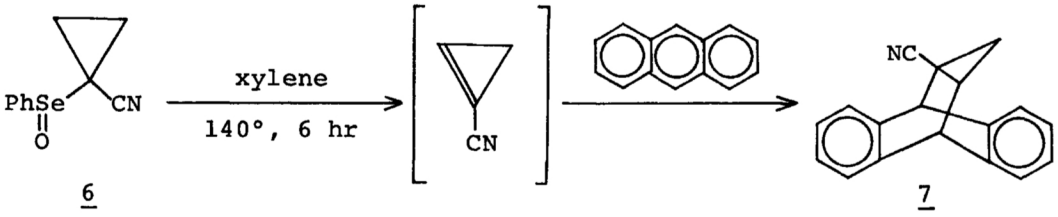
2 or 3 [a]		Yield	4	Yield(%) (E/Z)[c]		IR(cm^{-1})
RCH_2	R'	(%)		NCS	H_2O_2	$\nu_{C\equiv N}$
CH_3	H	96				
$CH_3(CH_2)_7$	H	92		93 (55/45)	91 (61/39)	2225
$PhCH_2$	H	92		85 (78/22)	97 (80/20)	2230
$PhCH{=}CHCH_2$	H	81		91 (42/58)	90 (26/74)	2230
$PhCH_2$	$PhCH_2$	88 (70)[b]		77 (0/~100)		2240

a, IR; $\nu_{C\equiv N}$ 2250~60 cm^{-1}. b, One step synthesis using 2 equiv. $PhCH_2Br$. c, The (E/Z) olefin ratio was determined by GLC (10% SE-30, Chromosorb W 60/80) and NMR.

In consequence of the further investigation of oxidation, we found that both hexabutyldistannoxane (HBD)-bromine (Br_2)[7] and sodium metaperiodate ($NaIO_4$) were good oxidants. Cyclopropyl selenoxide (6)[5] was isolated by the method (A) or (B) in 60% yield, mp 90~91°, IR; $\nu_{C\equiv N}$ 2260, $\nu_{Se=O}$ 840 cm^{-1}, NMR($CDCl_3$); δ=0.93~1.63 (4H, m), 7.43~7.70 (5H, m).



The treatment of 6 with anthracene in refluxing xylene for 6 hr gave 7[5] in 45% yield, mp 162~164°, IR; $\nu_{C\equiv N}$ 2270, δ_{PhH} 754 cm^{-1}, NMR($CDCl_3$); δ=0.48 (1H, dd J=7.0, 4.0 Hz), 1.23 (1H, dd J=7.0, 7.0 Hz), 1.90~2.30 (1H, m), 4.41 (1H, d J=4.5 Hz), 4.51 (1H, s), 6.93~7.35 (8H, m).



Consequently, cyclopropyl selenoxide (6) serves as a useful precursor for 1-cyanocyclopropene. This elimination at relatively low temperature seems to be characteristic of selenium compounds in comparison with sulfur analogues.

The present method has potential synthetic utilities in the following respects.

1) The starting material, cyanomethyl phenyl selenide (1), is readily accessible.
2) The alkylation has the high selectivity for mono- and di-alkylation at room temperature in aqueous medium.

Further studies for utilizing characteristics of selenium compounds are in progress.

References and Footnotes

1) H. J. Reich, J. M. Renga, and I. L. Reich, J. Am. Chem. Soc., 97, 5434 (1975) and references cited therein.
2) E. V. Dehmlow, Angew. Chem. Internat. Edit. Engl., 13, 170 (1974); M. Makosza, Pure Appl. Chem., 43, 439 (1975).
3) Y. Masuyama, Y. Ueno, and M. Okawara, Tetrahedron Lett., 1976, 2967.
4) Compound 1 was obtained from chloroacetonitrile and sodium benzeneselenolate (PhSeNa) at 0~5°C in ethanol in 92% yield, bp 137~138°/5mmHg, NMR(CCl_4); δ=3.17 (2H, s), 7.07~7.33, 7.37~7.63 (5H, m).
5) The yields given are for isolated products and the purification is carried out by means of recrystallization or column chromatography. All compounds obtained here exhibited satisfactory spectral and physical properties.
6) This cyclopropene synthesis is the first example taking advantage of the elimination of selenium compounds. An attempt of the deseleninylation of α-phenylseleninylcyclopropyl phenyl ketone has been carried out by Reich, et al.[1] However, they could not confirm the formation of cyclopropenyl phenyl ketone.
7) Y. Ueno and M. Okawara, Tetrahedron Lett., 1976, 4597.

(Received May 19, 1977)