Two-phase Darzens Condensation Reaction with Octopus Compounds as a Catalyst

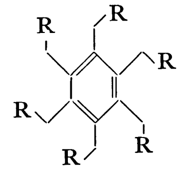
Sadatoshi Akabori,* Michiko Ohtomi, and Seiichi Yatabe
Department of Chemistry, Faculty of Science, Tōho University, Funabashi, Chiba 274

(Received September 27, 1979)

Synopsis. The octopus compound, readily derived from hexakis(mercaptomethyl)benzene and 1-chloro-3,6,9-trioxadecane, was effectively employed as a catalyst in the two-phase Darzens condensation of carbonyl compounds with chloroacetonitrile to afford the corresponding oxiranes in good yields.

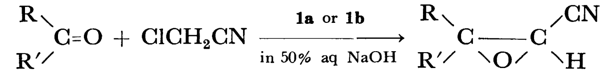
In recent years, phase-transfer catalyses involving crown ether and quarternary ammonium halide have come into widespread use as a tool in organic synthesis.[1] The use of crown ether[2] and quarternary ammonium salts[3,4] to catalyze Darzens condensations with a wide variety of substrates has also been documented; however, to the best of the authors' knowledge, no mention has been made in the literature of condensation reactions catalyzed by an octopus compound. In the course of our studies of the phase-transfer reaction we have found[5] that octopus compounds are useful phase-transfer catalysts for the synthesis of nitriles from the reaction of alkyl halide and sodium cyanide. Therefore, we wish now to describe a convenient and efficient Darzens condensation of ketones with chloroacetonitrile catalyzed by octopus compounds.

The reaction was conducted by stirring a mixture of a carbonyl compound, an excess of chloroacetonitrile, and 50% aq. sodium hydroxide at 15 °C in the presence of an octopus-compound catalyst (**1a** or **1b**). The results are shown in Table 1. The maximum yields of the condensation products under our experimental conditions were obtained by using about 6—9% of the octopus compound by weight to the carbonyl compound. The reaction is exothermic, and the controlled addition of chloroacetonitrile is sometimes necessary. The octopus compounds functions as liquid-liquid phase transfer catalysts: however, the reaction proceeds at a slower rate in the absence of the catalyst. For example, cyclohexanone (**2a**) gives less than 9% of **3a** after 5 h at 15 °C when it is treated with chloroacetonitrile in the absence of **1**, whereas **3a** is formed in a 76% yield within 2 h when **1** is present. Thus, in the Darzens condensation of carbonyl compounds, it is most likely that octopus compounds transport the hydroxide anion into the organic phase, although the possibility of transforming the carbonyl compound into the aqueous phase can not be ruled out. When hexakis(2,5,8,11-tetraoxadodecyl)benzene (**1b**) was employed as the phase-transfer catalyst, the results were usually quite similar,



1a, R = $-SCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_3$

1b, R = $-OCH_2CH_2OCH_2CH_2OCH_2CH_2OCH_3$



2 **3**

2 and **3**	**a**	**b**	**c**	**d**	**e**
R	$-(CH_2)_5-$	CH_3CH_2-	Ph-	CH_3-	CH_3- Ph-
					and
R′		CH_3CH_2-	Ph-	CH_3-	Ph- CH_3-

Table 1. Darzens condensation in the presence of octopus compounds

Carbonyl compound ($\times 10^{-3}$ mol)	$ClCH_2CN$ (ml)	50% NaOH (ml)	Octopus compound ($\times 10^{-5}$ mol)	Reaction time h	Reaction temp °C	Product[a)]	Yield %[b)]
2a (1.2)	0.1	2.0	**1a** (7.0)	3	15	**3a**	76
2a (1.2)	0.1	2.0	**1a** (20.0)	3	15	**3a**	40
2a (1.2)	0.1	2.0	**1a** (3.5)	3	15	**3a**	32
2a (1.2)	0.1	2.0	**1b** (7.0)	3	15	**3a**	56
2b (1.0)	0.1	2.0	**1a** (7.0)	3	15	**3a**	45
2b (1.0)	0.1	2.0	**1a** (20.0)	3	15	**3b**	40
2b (1.0)	0.1	2.0	**1a** (3.5)	3	15	**3b**	28
2b (1.0)	0.1	2.0	**1b** (6.5)	3	15	**3b**	23
2c (1.2)	0.1	2.0	**1a** (8.1)	3	15	**3c**	56
2c (1.2)	0.1	2.0	**1b** (9.1)	3	15	**3c**	51
2d (1.2)	0.1	2.1	**1a** (8.2)	3	15	**3d**	59
2d (1.2)	0.1	2.0	**1b** (9.1)	3	15	**3d**	33
2e (1.2)	0.1	2.0	**1a** (7.3)	1	15	**3e**[c)]	78[d)]
2e (1.2)	0.1	2.0	**1b** (7.3)	1	15	**3e**[c)]	75[d)]

a) All the products show the same retention time with the authentic sample. b) The values are those obtained by GLC. c) The product (**3e**) was found to be a nearly 1:1 mixture of geometrical isomers (*E*- and *Z*-isomers). d) The total yield of *E*- and *Z*-isomers.

although rather less satisfactory. In the case of acetophenone, the condensation product was shown by the GLC analysis to be a 1:1 mixture of geometrical isomers (*E*- and *Z*-). The yield of **3c** shown in the table is the total yield of *E*- and *Z*-isomers. In further experiments, similar reactions of cyclohexanone (**2a**) or benzophenone (**2c**) with chloroacetonitrile in the presence of 18-crown-6 as a phase-transfer catalyst afforded 1-oxa-spiro-[2,5]-octane-2-carbonitrile (**3a**, 55% yield) or 3,3-diphenyloxirane-2-carbonitrile (**3c**, 47% yield).

Experimental

Analysis. The products were analyzed by gas chromatography. The chromatograms were obtained on a Hitachi 023 gas chromatograph, using 10% Polyester FF on a Chromosorb W AW/DMCS 1 m×3 mm column.

Materials. Hexakis(2-thia-5,8,11-trioxadodecyl)benzene (**1a**) and hexakis(2,5,8,11-tetraoxadodecyl)benzene (**1b**) were prepared according to the procedures described in a previous paper.[5] Authentic samples (1-oxa-spiro[2.5]-octane-2-carbonitrile (**3a**),[6] 3,3-diethyloxirane-2-carbonitrile (**3b**),[7] 3,3-diphenyloxirane-2-carbonitrile (**3c**),[7] 3,3-dimethyloxirane-2-carbonitrile (**3d**),[6] and 3-methyl-3-phenyloxirane-2-carbonitrile (**3e**, *E*-+*Z*-isomers))[6] were prepared according to the procedures described in the literature. Sodium hydroxide and ketones were used without further purification. The solvents used were purified by distillation.

General Procedure. A typical procedure for the reaction of cyclohexanone with chloroacetonitrile is as follows.

*Reaction of Cyclohexanone with Chloroacetonitrile in the Presence of **1a**.* A solution of 50% aq. sodium hydroxide (2 ml), cyclohexanone (1.2×10^{-3} mol), and hexakis(2-thia-5,8,11-trioxadodecyl)benzene (7.0×10^{-5} mol) was stirred for 10 min at 15 °C. Chloroacetonitrile (0.1 ml) was then added all at once, and the heterogeneous mixture (organic–water layers) was stirred for a further 2 h at 15 °C. The reaction mixture was diluted with water (10 ml) and extracted with ether (3×10 ml). The extract was washed with water and dried with anhydrous magnesium sulfate. The solvent was evaporated, and the residue in benzene was subjected to GLC analysis.

References

1) W. P. Weber and G. W. Gokel. "Phase-transfer Catalysis in Organic Synthesis," Springer-Verlag KG. (1977).

2) M. Makosza and M. Ludwikow, *Angew. Chem.*, **86** 744 (1974).

3) J. C. Hummelen and H. Wynberg, *Tetrahedron Lett.*, **1978**, 1089.

4) A. Jonczyk, A. Kwast, and M. Makosza, *J. Chem. Soc., Chem. Commun.*, **1977**, 902.

5) M. Ohtomi, S. Yoneyama, K. Arai, and S. Akabori, *Nippon Kagaku Kaishi*, **1976**, 1878.

6) A. Jonczyk, M. Fedorynski, and M. Makosza, *Tetrahedron Lett.*, **1972**, 2395.

7) V. F. Martynov and A. V. Shchelkunov, *Zh. Obshch. Khim.*, **28** 3248 (1958).