

Synthesis of Cyclopentane Derivatives by Electrochemical
Reduction of 1,5-Dibromopentane Derivatives

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When 1,5-dibromopentane derivatives, which were prepared by CuBr-catalyzed photochemical reaction of 1,3-dibromopropane or its derivatives with electron-deficient olefins, were subjected to electrochemical reduction in THF or DMSO solution, cyclopentane derivatives were obtained.

A variety of methods have been proposed for construction of the cyclopentane ring system since the cyclopentane skeleton is one of the most important building units as found widely in a number of biologically active compounds. Among them, there are the intramolecular coupling procedures from 1,5-dihalides by the Wurtz-type reaction. However, this type of reaction generally gives only low yields of cyclopentane derivatives except for the case using the special device such as a silver salt.¹⁾ Although the electrochemical reduction may also cause the intramolecular coupling reaction of 1,5-dihalides, few examples have been except for that of dimethyl 2,6-dibromopimelate, the 1,5-dihalide containing alkoxycarbonyl groups at both termini, in THF solution²⁾ because this method seems to be limited to the 1,5-dihalides having electron-withdrawing groups.³⁾ We have found that 1,5-dibromopentane derivatives are obtained by Cu(I)-catalyzed photochemical addition of 1,3-dibromopropane to electron-deficient olefins.⁴⁾ We wish to report here that thus obtained 1,5-dibromopentanes containing the electron-withdrawing group at one terminus give a variety of cyclopentanes by electrochemical reduction in THF or DMSO solution.

2,6-Dibromohexanenitrile (1a) which was obtained from 1,3-dibromopropane and acrylonitrile according to our previously reported method⁴⁾ was electrolyzed in THF solution containing (n-Bu)₄NClO₄ (0.2 mol dm⁻³) as supporting electrolyte in an undivided cell with carbon electrodes as anode and cathode. After electricity of 2.2 F mol⁻¹ was passed at a constant current of 50 mA, THF was evaporated and then the product was extracted with ether. After removal of ether, the product was isolated in 66% yield by silica-gel chromatography and identified as cyclopentanecarbonitrile (2a) by ¹H-NMR and IR spectra. Electroreduction of 1a was performed also in DMSO solution containing Et₄NOTs (0.2 mol dm⁻³). After electricity of 3 F mol⁻¹ was passed at a constant current of 50 mA, the DMSO solution was poured into water and the product was extracted with ether. 2a was isolated in 60% yield by silica-gel chromatography. The results of electroreduction of 1,5-dibromopentane derivatives prepared from 1,3-dibromopropane or 2-substituted-1,3-dibromopropanes

and various olefins are summarized in Table 1. As a mechanism of this electrochemical cyclization, we suppose that the carbon-bromine bond adjacent to the electron-withdrawing group may be initially reduced to generate a carbanion which may in turn attack the terminal carbon bearing bromine atom. It remains to be clarified why 2c was produced only as the minor product in electroreduction of 1c although it might be its reason that the enolate anion generated in electroreduction of 1c would be hard to do intramolecular attack on the carbon bearing bromine atom due to its low nucleophilicity. Although ^1H -NMR spectra reveal that 2g-n are composed of mixtures of stereoisomers, the diastereomeric purities of the starting 1,5-dibromopentanes are not confirmed at present stage and thus the stereochemical course of electroreductive cyclization is the subject to detailed studies in future.

Table 1. Electroreduction of 1,5-dibromopentane derivatives

	R_1	R_2	R_3	R_4	Solvent	Yield of <u>2</u> / % ^{a)}
<u>a</u>	H	H	H	CN	THF	66 (84)
					DMSO	60 (78)
<u>b</u>	H	H	H	COOEt	THF	54 (77)
					DMSO	(57)
<u>c</u>	H	H	H	COMe	THF	10 ^{b)}
<u>d</u>	H	H	Me	CN	THF	67 (85)
					DMSO	(78)
<u>e</u>	H	H	Me	COOEt	THF	68 (87)
<u>f</u>	H	H	CH ₂ COOEt	COOEt	THF	53 (70)
					DMSO	(66)
<u>g</u>	H	COOEt	H	COOEt	THF	49 (65)
<u>h</u>	Me	H	H	CN	THF	63
<u>i</u>	Me	H	H	COOEt	THF	60
<u>j</u>	Me	H	Me	CN	THF	64
<u>k</u>	Me	H	CH ₂ COOEt	COOEt	THF	53
<u>l</u>	CH ₂ CH=CH ₂	H	H	CN	THF	60
<u>m</u>	CH ₂ CH=CH ₂	H	H	COOEt	THF	55
<u>n</u>	OAc	H	H	CN	THF	50

a) Yields isolated by silica-gel chromatography. Parentheses show VPC yields.

b) The major product was $\text{Br}(\text{CH}_2)_5\text{COMe}$ (60%).

References

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