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Drynap Reduction. IV. The Reduction of Cyclic Styrene Derivatives with a Commercial Sodium-Lead Alloy

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In a previous paper of this series, one of the present authors reported that a commercial sodium-lead alloy, "Drynap", can be used as a reducing agent in the reduction of α,β-unsaturated carbonyl compounds in place of a sodium amalgam.[1]

In the present experiment, the alloy was used in the reduction of four cyclic styrene derivatives: coumarin, isocoumarin, *N*-methylcarbostyril, and isocarbostyril. A little of the information thus obtained will be reported here.

The reduction of coumarin with Drynap in an aqueous sodium hydroxide solution was attempted using the method of Erlenmeyer[2]; 3,4-dihydrocoumarin was thus obtained in about a 70% yield, as was expected. Isocoumarin, *N*-methylcarbostyril, and isocarbostyril were not reduced with the alloy in an aqueous solvent; isocoumarin was, thereby polymerized in an alkaline solution, even in the cold, and a yellowish brown tar was obtained. *N*-methylcarbostyril and isocarbostyril were recovered almost quantitatively.

In an ethanolic solution, coumarin was reduced with Drynap to 3,4-dihydrocoumarin in a 20% yield, but the main products were two isomers of 3,3′,4,4′-tetrahydro-4,4′-bicoumarin (the total yield of the mixture was about 50%). The mixture was separated by the method of Asahina and Fujita *via* the fractional crystallization of the corresponding carboxylic acid.[3] and two compounds which were difficult to separate were thus obtained: a less soluble isomer, mp 278—280°C (decomp.), and a more soluble one, mp 246—248°C (decomp.). Harle and Lyons have already assigned the above two isomers to the meso and

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[1] K. Tabei, H. Hiranuma and N. Amemiya, This Bulletin, **39**, 1085 (1966).

[2] A. Erlenmeyer, *Ann. Chem.*, **121**, 375 (1862); **137**, 334 (1866).

[3] Y. Asahina and Y. Hujita, *Yakugaku Zasshi*, **444**, 97 (1915).

[4] A. J. Harle and L. W. Lyons, *J. Chem. Soc.*, **1950** 1575.

racemic forms respectively.[4] The IR and NMR spectra of the compound can not be discussed in detail in the present report.

The NMR spectra of the latter compound, the more soluble isomer, revealed doublet signals of methylene protons attached to the carbonyl group at 6.92 τ (4H), and triplet signals of the methine proton attached to the phenyl group at 7.00 τ (2H), in the deuteriochloroform solution, so it is certain that the dihydrocoumarin rings are united at the 4-position.

N-Methylcarbostyril was reduced with Drynap in the manner which has been described for use with coumarin; a new dimeric reduction product, $C_{20}H_{20}N_2O_2$, (mp 284—286°C) was thus obtained in about a 60% yield. The mass spectra of the dimer gave a characteristic peak of the monomer ion at *m/e* 160 as well as the molecular ion peak at *m/e* 320. The out-of-plane deformation vibration of olefinic hydrogen of *N*-methylcarbostyril disappeared in the IR spectra of the dimer, and the carbonyl stretching mode of the dimer absorbed in a wavelength region shorter by 12 cm^{-1} at 1673 cm^{-1}. The NMR spectra of the dimer exhibit the doublet signals of methylene protons adjacent to carbonyl group at 7.37 τ (4H). and triplet signals of the methine proton adjacent to the phenyl ring at 7.17 τ (2H), in the deuteriochloroform solution. The product can thus be identified as 3,3′,4,4′-tetrahydro-1,1′-dimethyl-4,4′-bicarbostyril.

Isocoumarin and isocarbostyril were also not reduced with Drynap in an ethanolic solution; isocoumarin gave a yellow tar, and isocarbostyril was recovered from the reaction mixture.

The above results were not improved by several alterations of the reduction conditions. We can thus conclude that the α,β-unsaturated carbonyl group is necessary for the Drynap reduction or reductive dimerization of cyclic styrene derivatives, even in a limited experiment.

Experimental

Materials. Commercial coumarin of a GR grade was purified by distillation under reduced pressure before use. The isocoumarin was synthesized from homophthalic acid *via* the decarboxylation of 4-carboxyisocoumarin, following the method of Johnston *et al.*[5] The product was purified by distillation at 155°C/20 mmHg; mp 45°C.

The *N*-methylcarbostyril was derived from quinoline methiodide following the method of Decker.[6] The product was purified by recrystallization from ligroin; mp 72—73°C.

The isocarbostyril was also derived from isoquinoline by the method of Brown and White.[7] The product was purified by recrystallization from methanol; mp 213—214°C.

Measurement of the Spectra. The IR spectra of the compounds were measured by using a JASCO DS-301 infrared spectrophotometer and using tablets of potassium bromide or in a chloroform solution.

The NMR spectra of the compounds were measured by using a JNM 4H-100 NMR spectrometer in a deuteriochloroform solution.

The mass spectra of the reduced dimers were measured by using a Hitachi RMU-7L apparatus.

Drynap Reduction of Coumarin in a Sodium Hydroxide Solution. Three grams of coumarin (0.02 mol) dissolved in 50 m*l* of a 5% NaOH solution were reduced with 30 g of Drynap (0.13 mol of sodium metal): the reaction procedure was the same as has been described in a previous report. The yield of 3,4-dihydrocoumarin was 2.2 g (73%); bp 142—144°C/7 mmHg, mp 24°C. Dihydrocoumarin was identified by a mixed-melting-point determination with an authentic derivative; 3,5-dibromo-2-hydroxyphenylpropionic acid, mp 117—118°C, and by IR and NMR spectral studies of dihydrocoumarin. From the distillation residue, 0.2 g of the starting material, 2-hydroxycinnamic acid, was recovered; mp 207—208°C.

Drynap Reduction of Coumarin in an Ethanolic Solution. To a solution of 3.0 g of coumarin in 50 m*l* of ethanol, 30 g of Drynap and 7.5 g of acetic acid (0.12 mol) were added alternately in small portions at 60—70°C. After 1.5—2.0 hr, the mixture was decanted from the sludge, which was then washed with a new ethanol. The ethanol was evaporated from the combined ethanol solution, and the resultant residue was extracted with ether.

Some of the insoluble material remained after the above extraction. The ether solution was washed with a 5% sodium hydrogencarbonate solution and then with water, and dried over sodium sulfate. After the evaporation of the ether, the residual oil was distilled under reduced pressure; 0.6 g of 3,4-dihydrocoumarin was thus obtained (yield 20%); bp 142—144°C/7 mmHg.

From the distillation residue and the above-cited insoluble material, 1.5 g of a mixture of the two isomeric dimeric reduction products were obtained (total yield, 50%).

Separation of Isomeric Dimers. The isomeric mixture was dissolved in a 10% sodium hydroxide solution and hydrolyzed by boiling. After the acidification of the alkaline solution with concentrated hydrochloric acid, the water-soluble 3,4-bis-(2-hydroxyphenyl)adipic acid thus obtained was extracted with ether and then subjected to fractional crystallization from ether.

A less soluble acid (0.1 g, mp 200—220°C (decomp.)) and a more soluble isomer (0.7 g, mp 153—155°C (decomp.)) were thus obtained.

The acids were re-lactonized, by boiling in a mixture of acetic acid and a few drops of conc. hydrochloric acid, to the corresponding tetrahydro-bicoumarin. After several recrystallizations from glacial acetic acid, 300 mg of the less soluble lactone was obtained from the less soluble acid; mp 278—280°C (decomp.); Found: C, 73.65; H, 4.88%, mol wt (mass) *m/e* 294.

The other acid gave 0.5 g of the more soluble lactone; mp 246—248°C (decomp.); Found: C, 73.46; H,

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[5] H. W. Johnston, C. E. Kaslow, A. Langsjeon and R. I. Shriner, *J. Org. Chem.*, **13**, 477 (1948).

[6] H. Decker, *Ber.*, **25**, 443 (1892).

[7] R. B. Brown and D. White, *J. Chem. Soc.*, **1957**, 1589.

4.80%, mol wt (mass) *m/e* 294. $\nu_{C=O}$ 1764 cm^{-1}, H-3; 6.92 τ (4H) doublet (*J*=4 Hz), H-4; 7.00 τ (2H) triplet.

Drynap Reduction of *N*-Methylcarbostyril in an Ethanolic Solution. A mixture of 3.5 g of *N*-methylcarbostyril (0.02 mol) and 50 m*l* of ethanol was reduced with 30 g of Drynap and 7.5 g of acetic acid following the method described in the case of coumarin. The crude product was extracted with ethyl acetate, and the extracted product was recrystallized from ethanol. Rhombic crystalls were thus obtained (1.7 g); mp 284—286°C; Found: C, 75.19; H, 6.50; N, 8.86%; mol wt (mass), *m/e* 320. Calcd. for $C_{20}H_{20}N_2O_2$; C, 74.97; H, 6.29; N, 8.74%. $\nu_{C=O}$ 1673 cm^{-1}, N-CH_3 7.67 τ (6H) singlet, H-3; 7.37 τ (4H) doublet (*J*=4 Hz), H-4; 7.17 τ (2H) triplet.

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