BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN, VOL. 49 (11), 3333—3334 (1976)

Heterocycles by Cycloaddition. III.[1] Dihydroisoindolequinone, the Correct Structure of the Proposed Azatetracyclononanedione

Hiroshi MATSUKUBO* and Hiroshi KATO**

Department of Chemistry, Faculty of Science, Shinshu University, Asahi, Matsumoto 390

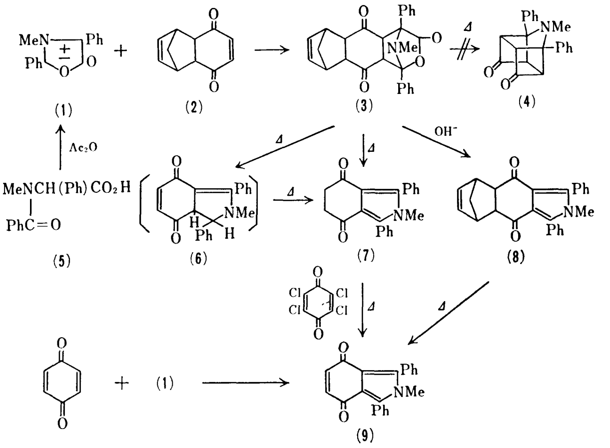
(Received May 6, 1976)

Synopsis. Pyrolysis of a cyclopentadienequinone–oxazolone adduct (**3**) gives a 5,6-dihydro-4,7-isoindolequinone (**7**) and not an azatetracyclic cage compound (**4**). The dihydroquinone (**7**) was dehydrogenated to the corresponding isoindolequinone (**9**), which was synthesized *via* alternative routes.

The cycloaddition–extrusion of five-membered mesoionic compounds has been utilized for the preparation of a wide variety of heterocyclic systems.[2] The reaction with an olefin usually gives a dihydro heterocyclic compound by migration of a substituent, but with some dipolarophiles, the transient ylide formed by the cycloaddition–extrusion reaction, is trapped by the dipolarophile to give a 1 : 2 adduct.[3] When a dipolarophile has two double bonds within the molecule with a suitable framework, the initially formed ylide can be trapped intramolecularly to give a cage compound. Such cage compounds have been prepared by the reactions of a sydnone with cyclooctadiene[4] and butadienes.[5]

As an extreme case of such a double intramolecular cycloaddition, Myers *et al.*[6] recently claimed the formation of 8-aza-7,9-diphenyl-8-methyltetracyclo-$[4.3.0.^{3,9}0^{4,7}]$nonane-2,5-dione (**4**) by pyrolysis of 1,3,3a,4,4a,5,8,8a,9,9a-decahydro-5,8-methano-2-methyl-4,9-dioxo-1,3-diphenyl-2*H*-benz[*f*]isoindole-1,3-carbolactone (**3**),[7] the adduct of the mesoionic 3-methyl-2,4-diphenyl-5-oxazolone (**1**) and cyclopentadienequinone (**2**).

The spectral data of the product (**A**), however, do not appear to be in agreement with the proposed structure **4**. For example, the reported infrared carbonyl band of **A** at 1665 cm^{-1} is too low for a strained cyclobutanone system,[8] and the ultraviolet absorption maximum at 308 nm suggests an aromatic or a conjugated chromophor. We thought that these data are more compatible with 5,6-dihydro-2-methyl-1,3-diphenyl-4,7-isoindolequinone (**7**) than with **4**. It was found that the NMR singlet at δ 2.88 disappeared by base-catalyzed treatment of **A** with deuterium oxide. This shows that the carbonyl group of the product **A** is enolizable, and it cannot reconcile with the proposed structure **4**. Dehydrogenation of the product **A** with chloranil gave 2-methyl-1,3-diphenyl-4,7-isoindolequinone (**9**). The structure of the quinone **9** was established by an independent synthesis by pyrolysis of 4,4a,5,8,8a,9-hexahydro-5,8-methano-2-methyl-1,3-diphenyl-2*H*-benz[*f*]isoindole-4,9-dione (**8**),[6] or alternatively, by the cycloaddition–extrusion–dehydrogenation reaction of the mesoionic oxazolone **1** with *p*-benzoquinone.[9]



The above results show that the pyrolysis of the adduct **3** proceeds normally to give the dihydroisoindolequinone (**6**) by extrusion of carbon dioxide and cyclopentadiene, which isomerizes under the reaction conditions to **7** with an aromatic pyrrole ring. The ease and high yields of those reactions, however, should be considered as an indirect and yet an attractive synthetic method of many benzoquinones condensed with a heterocyclic ring, and their dihydro derivatives; because it has been known that the reactions of quinones and five-membered mesoionic compounds always give fully unsaturated systems by dehydrogenation with the quinones present in the reaction system,[9,10] and that the yields of such adducts are sometimes low due to the formation of by-products including the 1 : 2 adduct of benzoquinone and a mesoionic compound. Thus, we isolated **9** only in 8% yield by the reaction of benzoquinone with the mesoionic oxazolone **1**, and the formation in 17% yield of **9** by the same reaction under slightly different (*in situ*?) conditions is reported.[9]

Experimental

Mps were determined on a Yanagimoto hot-stage apparatus and are not corrected. UV and IR spectra were recorded on Hitachi EPS-3T and Hitachi EPI-G3 spectrophotometers. NMR and mass spectra were measured with JEOL JNM-4H-100 (100 MHz) and Hitachi RMU-6 spectrometers.

*Cyclopentadienequinone–Oxazolone Adduct (**3**).* This could conveniently be prepared by the *in situ* reaction: A soln of cyclopentadienequinone **2** (10 mmol) and 2-(*N*-methylbenzamido)-2-phenylacetic acid (**5**) (10 mmol) in acetic anhydride (30 ml) was stirred at 55—60 °C for 2 h under nitrogen. The crystals which separated out were collected and washed with benzene to give pure **3** (92%), mp 160—

---

* Present Address: Okaya Works, Kyorin Pharmaceutical Co., Kohan, Okaya 394.

** To whom inquiries should be addressed.

161 °C (dec) (lit,[6] 158—160 °C). Spectral data were identical with those reported.

Base-Catalyzed Deuteration of Dihydroisoindolequinone (7). A soln of **7** and a small amount of anhyd potassium carbonate in a mixture of dioxane and deuterium oxide was heated under reflux for 1 h. The soln was concd *in vacuo*, the residue was extracted with deuteriochloroform, and the extract was dried ($MgSO_4$) and was used for NMR measurement. The spectral pattern was identical with **7** except that the singlet peak at δ 2.88 disappeared completely.

2-Methyl-1,3-diphenyl-4,7-isoindolequinone (9). (*a*) A soln of **7** (0.2 g; 0.64 mmol) and chloranil (0.19 g; 0.78 mmol) in xylene (10 ml) was refluxed for 4 h. The solvent was removed *in vacuo*, the residue was extracted with chloroform, and the extract was washed with aq sodium hydroxide and water, dried ($MgSO_4$), and concd. The residue was recrystd from methanol to give orange prisms of **9** (0.2 g, 100%), mp 186—187 °C. UV_{max} (MeOH) 229 ($\log \varepsilon$ 4.42), 276 (4.13), and 418 nm (3.64); IR (KBr) 1655^{sh} and 1646 cm^{-1} (C=O); NMR ($CDCl_3$; TMS) 3.27 (s, 3, Me), 6.50 (s, 2, CH=), and 7.40 ppm (br s, 10, Ph); MS (70 eV; direct inlet) *m/e* (rel intensity) 313 (M^+, 100), 312 (69), and 118 (31). Found: C, 80.22; H, 4.65; N, 4.37%. Calcd for $C_{21}H_{15}NO_2$: C, 80.50; H, 4.83; N, 4.47%.

(*b*) A suspension of the methanobenz[*f*]isoindoledione **8**[6] (75 mg) in xylene (10 ml) was refluxed for 18 h. The solvent was removed *in vacuo* and the residue was chromatographed (silica gel/chloroform) and recrystd from methanol to give **9** (50 mg, 81%), identical with the specimen prepared by procedure (a).

(*c*) A soln of *p*-benzoquinone (0.43 g; 4 mmol) and the oxazolone **1** (0.5 g; 2 mmol) in benzene (20 ml) was stirred at room temperature for 3 h under nitrogen, and was then warmed for 3 h at 60 °C. The benzene extract of the reaction mixture was chromatographed (silica gel/chloroform) to give **9** (50 mg, 8%), identical with the specimen prepared by procedure (a).

We are indebted to Kyorin Chemical Laboratories for elemental and mass spectral analyses.

References

1) Part II, H. Kato, S. Nakazawa, T. Kiyosawa, and K. Hirakawa, *J. Chem. Soc., Perkin Trans. I,* **1976**, 672.

2) M. Ohta and H. Kato, "Nonbenzenoid Aromatics," Ed. J. P. Snyder, Academic Press, Vol. 1, New York (1969), p. 117.

3) H. Gotthardt and R. Huisgen, *Chem. Ber.*, **101**, 552 (1968); **103**, 2625 (1970); R. Huisgen, H. Gotthardt, and H. O. Bayer, *ibid.*, **103**, 2368 (1970).

4) P. M. Weintraub, *J. Chem. Soc., Chem. Commun.*, **1970**, 760.

5) A. Haneda, T. Imagawa, and M. Kawanishi, *Bull. Chem. Soc. Jpn.*, **49**, 748 (1976).

6) J. A. Myers, W. W. Wilkerson, and S. L. Council, *J. Org. Chem.*, **40**, 2875 (1975).

7) This is not the first example of cycloadduct of mesoionic 5-oxazolone retaining the lactone moiety as claimed by the authors.[6] For an earlier example, see: T. Shiba and H. Kato, *Bull. Chem. Soc. Jpn.*, **43**, 3941 (1970).

8) *Cf.* the carbonyl absorption of cyclobutanone at 1786 cm^{-1}: C. J. Pouchert, "The Aldrich Library of Infrared Spectra," Aldrich Chemical Co., Milwaukee (1970), p. 197.

9) H. Nagahiro, M. Hamaguchi, and T. Ibata, Abstr. 32nd National Meeting of the Chemical Society of Japan, Tokyo, April 1975, p. 1643.

10) D. L. Hammick and D. J. Voaden, *J. Chem. Soc.*, **1965**, 5871; *Chem. Ind.* (*London*), **1956**, 739; H, Brockmann and T. Reschke, *Tetrahedron Lett.*, **1965**, 4593.