

Heterocycles from Ketenimines. VIII. Bis-Oxazetidines (1a)

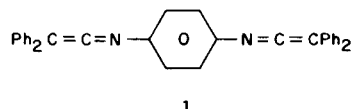
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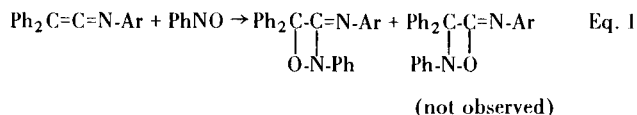
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Compounds containing two or more nonfused heterocyclic rings are common in natural products and as side reactions of standard heterocyclic syntheses (2). A recent review by Albert and Yamamoto shows that most syntheses of these "heterocyclic oligomers" are dimerization reactions or a step by step construction of the individual heterocycles (2). We have been interested in developing one step cycloaddition reactions to yield *bis*-heterocycles and wish to report the results of one of these studies.

Ketenimines (*N*-analogs of ketenes) have been shown to be general precursors for a number of heterocycles through simple 2 + 2 and 2 + 3 cycloadditions (3). The utilization of *bis*-ketenimines in these same cycloaddition reactions should result in the production of *bis*-heterocycles. The *bis*-ketenimine chosen for initial study was *N,N'*-*bis*(diphenylethenylidene)-1,4-benzenediamine (1).

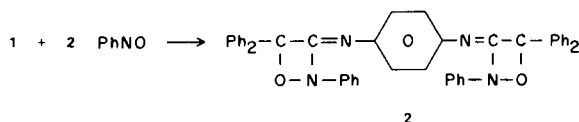


Its selection was based on knowledge that fully aromatic substituted ketenimines do not undergo dimerization readily while ketenimines possessing alkyl substituents may (4). Nitrosoarenes were chosen as the other component because the cycloaddition of monoketenimines and nitrosoarenes has been shown to yield only one of the two possible adducts (eq. 1)(5).

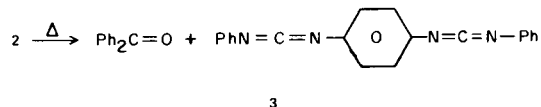


A two to one molar ratio of nitrosobenzene and 1 was dissolved in a minimum amount of carbon tetrachloride and the solution was allowed to stand for 24 hours at room temperature. An infrared spectrum of the reaction mixture at the end of this period showed no absorption for the ketenimine at 2000 cm^{-1} but absorption for the imine on a strained ring at 1706 cm^{-1} (5). Removal of the solvent and trituration of the resulting syrup with cyclohexane gave a 53% yield of solid which had an

elemental analysis consistent with a 2:1 adduct. These results plus our earlier work led us to propose 2 (3,3'-*p*-(phenylenedinitrilo)*bis*[2,4,4-triphenyl-1,2-oxazetidine]) as the adduct (Eq. 2). No other product was observed spectrally or chromatographically.



Structure proof of 2 was obtained through thermal degradation studies. After the adduct was heated to 110° at reduced pressure (0.2 mm) for two hours, a liquid was observed on the walls of the container and a dark solid was left at the bottom. The liquid exhibited an infrared absorption at 1650 cm^{-1} and a ge retention time identical to authentic benzophenone. The solid exhibited an infrared absorption at 2105 cm^{-1} ($-\text{N}=\text{C}=\text{N}-$) and had an analysis compatible with 3. No indication of an isocyanate or an



imine was ever observed indicating that as with the monoketenimine, each cycloaddition occurs to give only the 3-iminooxazetidine.

Bis-oxazetidines were also produced by the cycloaddition reaction of 1 with *p*-chloronitrosobenzene, *p*-bromonitrosobenzene, and *p*-nitrosotoluene. Thus, the reaction of *bis*-ketenimines and nitrosoarenes appears to be a general method for the synthesis of *bis*-oxazetidines by a one step cycloaddition reaction.

EXPERIMENTAL

Melting points were determined on a Mel-Temp apparatus and are corrected. Infrared spectra were determined in carbon tetrachloride, chloroform, potassium bromide, or neat on Perkin-Elmer Model 137 and 137G Infracords. The gas chromatography measurements were made on a Hewlett Packard Model 5750 instrument using a six foot 10% UCW98 on Chromosorb W column. Analyses were performed by Galbraith Laboratories, Inc., Knoxville, Tennessee.

N,N'-Bis(diphenylethenylidene)-1,4-benzenediamine (1).

This bis-ketenimine is mentioned in the patent literature (6), however, since no properties were listed, we include our preparation by the method of Bestmann, Lienert, and Mott (7).

Into a one liter, three-neck flask equipped with a nitrogen inlet tube, a mechanical stirrer, and a reflux condenser fitted with a drying tube were placed 500 ml. of methylene chloride (dried over molecular sieves for 24 hours) and 39.3 g. (0.15 mole) of triphenylphosphine (dried in a vacuum dessicator for 48 hours). Bromine was added from an equilibrium separatory funnel until a drop of bromine caused a permanent bromine color in the solution (about 24 g. of bromine, 0.15 mole). During the bromine addition, the solution was kept from refluxing from the heat of the bromination by cooling with an ice-water mixture. After the addition of the bromine an excess of triethylamine (111 ml., 0.80 mole) was added and the solution was purged with nitrogen. Then 37.2 g. (0.075 mole) of *p-N,N'*-phenylene-bis(diphenylacetamide) were added to the reaction mixture, the ice bath removed, and the solution refluxed for one hour. During this time, the solution became quite thick from the triethylamine hydrobromide which was formed. At the end of the reflux time, the reaction mixture was transferred to a one-liter round bottom flask and then evaporated to dryness using reduced pressure. Care was taken during this evaporation to remove the heat from the flask on the aspirator just before dryness so that the contents of the flask were not superheated. The dry contents of the flask were extracted three times with 300 ml. portions of hot cyclohexane.

The combined cyclohexane extracts was allowed to stand overnight during which time most of the triphenylphosphine oxide and bis-ketenimine precipitated. The cyclohexane was decanted and the residue was washed with cold methanol to remove triphenylphosphine oxide. The 12.2 g. (35.4%) of collected solid was recrystallized from cyclohexane to give an analytically pure sample, m.p. 180-182°.

Anal. Calcd. for $C_{34}H_{24}N_2$: C, 88.66; H, 5.25; N, 6.08. Found: C, 88.50; H, 5.36; N, 6.04.

3,3'-(*p*-Phenylenedinitrilo)-bis-[2,4,4-triphenyl-1,2-oxazetidine] (2).

One hundred milliliters of dry carbon tetrachloride was added to an erlenmeyer flask which contained 2.30 g. (0.005 mole) of 1. The solvent had to be warmed to effect solution of the ketenimine. After cooling, 1.07 g. (0.01 mole) of nitrosobenzene (freshly recrystallized from hexane) was added and the solution was allowed to stand for 24 hours at room temperature. At the end of this time period, the infrared spectrum indicated that the ketenimine had disappeared (no 2000 cm^{-1} absorption) and thin layer chromatography indicated the presence of only one compound in the reaction mixture.

The reaction mixture was placed on the flash evaporator and reduced to a dark colored syrup without external heating. This syrup was triturated with cyclohexane and 1.80 g. (53.4%) of solid separated from the solvent. The adduct was recrystallized from benzene-cyclohexane to yield an analytically pure sample, m.p. 138-139°; ir: 1704 cm^{-1} (s).

Anal. Calcd. for $C_{46}H_{34}N_2O_2$: C, 81.87; H, 5.08; N, 8.30. Found: C, 82.01; H, 4.99; N, 8.14.

3,3'-(*p*-Phenylenedinitrilo)-bis[4,4-diphenyl-2-*p*-chlorophenyl-1,2-oxazetidine].

One hundred milliliters of dry carbon tetrachloride, 2.30 g. (0.005 mole) of 1, and 1.42 g. (0.01 mole) of *p*-chloronitrosobenzene were treated as previously described to yield 3.14 g.

(84.4% yield) of crude adduct which when recrystallized from cyclohexane-benzene melted at $149-151^\circ$; ir: 1706 cm^{-1} (s).

Anal. Calcd. for $C_{46}H_{32}N_4O_2Cl_2$: C, 74.29; H, 4.34; N, 7.53. Found: C, 74.44; H, 4.44; N, 7.31.

3,3'-(*p*-Phenylenedinitrilo)-bis[4,4-diphenyl-2-*p*-tolyl-1,2-oxazetidine].

One hundred ml. of dry carbon tetrachloride, 2.30 g. (0.005 moles) of 1, 1.21 g. (0.01 moles) of *p*-nitrosotoluene were treated as described to yield 2.93 g. (83.5% yield) of crude adduct. Recrystallization from cyclohexane-benzene gave tan crystals, m.p. $129-130^\circ$; ir: 1706 cm^{-1} (s).

Anal. Calcd. for $C_{48}H_{38}N_4O_2$: C, 82.03; H, 5.45; N, 7.97. Found: C, 82.13; H, 5.51; N, 7.87.

3,3'-(*p*-Phenylenedinitrilo)-bis[4,4-diphenyl-2-*p*-bromophenyl-1,2-oxazetidine].

One hundred ml. of dry carbon tetrachloride, 2.30 g. (0.005 mole) of 1, and 1.86 g. (0.01 mole) of *p*-bromonitrosobenzene were treated as described and 1.71 g. (41.0% yield) of crude adduct was obtained. Recrystallization from cyclohexane-benzene yielded tan crystals, m.p. $147-147.5^\circ$; ir: 1706 cm^{-1} (s).

Anal. Calcd. for $C_{46}H_{32}N_4O_2Br_2$: C, 67.52; H, 4.05; N, 6.43. Found: C, 67.53; H, 3.89; N, 6.57.

Proof of Structure of the Bis-Heterocycles.

The purified adducts were each heated separately in a drying pistol at 0.2 mm pressure for two hours over refluxing toluene. During this time, a colorless liquid (benzophenone) separated into the cooler part of the drying pistol leaving a dark solid in the sample vessel (carbodiimide).

The identity of the benzophenone was shown in each case by infrared analysis (1650 cm^{-1}) and retention time on a gas chromatograph as compared to an authentic sample. (8).

The presence of the carbodiimide was indicated by infrared analysis (2105 cm^{-1}). However, *p*-phenylene-bis(phenylcarbodiimide) is reported to have a melting point of $69-70^\circ$ (9) while the sample from thermal degradation of 2 had a melting point of $149-150^\circ$. Elemental analysis confirmed our structure assignment.

Anal. Calcd. for $C_{20}H_{14}N_4$: C, 77.40; H, 4.55; N, 18.05. Found: C, 77.24; H, 4.61; N, 17.80.

A 0.6616 g. (.0009 mole) sample of the adduct of 1, and *p*-chloronitrosobenzene yielded 0.3397 g. (99%) of the corresponding carbodiimide upon thermolysis demonstrating that only the adduct analogous to 2 is formed in these cycloadditions.

Acknowledgement.

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REFERENCES

- (1a) Part VII: M. W. Barker and J. D. Rosamond, *J. Heterocyclic Chem.*, 11, 241 (1974); (b) CJW on leave from the Mississippi State College for Women, Columbus, Mississippi, 1973-1974.
- (2) A. Albert and H. Yamamoto, in "Advances in Heterocyclic Chemistry", Vol. 15, A. R. Katritzky & A. J. Boulton, Eds., Academic Press, New York, N. Y., 1973, p. 1.
- (3) M. W. Barker and J. T. Gill, *J. Heterocyclic Chem.*, 7, 1203 (1970); M. W. Barker and J. H. Gardner, *ibid.*, 6, 251 (1969) and 5, 881 (1968), and M. W. Barker and M. E. Coker,

ibid., 4, 155 (1967).

(4) M. W. Barker and J. D. Rosamond, *ibid.*, 9, 1147 (1972) and J. D. Rosamond, Ph.D. Dissertation, Mississippi State University, August, 1971.

(5) M. W. Barker and J. T. Gill, *J. Heterocyclic Chem.*, 7, 1203 (1970).

(6) E. Molenaar (Akzona Incorporated, Ashville, North Carolina) U.S. Patent 3,692,745 (1972).

(7) H. J. Bestmann, J. Lienert, and L. Mott, *Ann. Chem.* 78,

24 (1968).

(8) Authentic benzophenone gave a gc retention time of 142 seconds under the following conditions; sample size 1 μ l; flow rate 2.5 ml./min. of He; column temperature 260°, injection port temperature 240°, and flame detector temperature 300°. Under the same conditions, the liquid sample from each thermal degradation had a retention time of 141 seconds.

(9) T. C. P. Lee and R. T. Wragg, *J. Appl. Polymer Sci.*, 14, 115 (1970).