Anal. Calcd. for $C_{17}H_{23}NO$: C, 79.33; H, 9.01; N, 5.44. Found: C, 79.44; H, 9.24; N, 5.54.

endo-3-Dimethylaminomethyl-5-norbornen-2-yl exo-phenyl ketone (VII). Pyridine, 200 ml., was cooled in an ice bath and 13.3 g. of chromic oxide was added in portions with thorough mixing. To the resulting complex was added a solution of 13.32 g. of aminoalcohol VI in 80 ml. of pyridine. The resulting dark mixture was allowed to stand at room temperature for 22 hr. and then was treated with 280 ml. of water. This mixture was extracted three times with ether, washing each ether extract with a small portion of water, which was added to the pyridine-water reaction mixture. The combined ethereal extracts were dried over magnesium sulfate and concentrated to dryness, finally with pumping under high vacuum, to give 8.39 g. (63%) of crude VII as a dark oil; λ_{max}^{neat} 5.96 μ (ketone C=O), 6.25 μ (aromatic C=C).

The hydrogen fumarate prepared from 3.39 g. (0.0133 mole) of VII and 1.54 g. (0.0133 mole) of fumaric acid in isopropyl alcohol–ether amounted to 3.67 g. (over-all 47%) melting at 144–146°; λ_{max}^{Nujol} 3.0 (broad, —OH), 5.78 (carboxyl C=O), 5.92 (ketone C=O), 6.03 (C=C), 6.35 μ (carboxylate C=O); λ_{max} 244 mμ (ϵ 16,500).

Anal. Calcd. for $C_{17}H_{21}NO \cdot C_4H_4O_4$: N, 3.77. Found: N, 3.97, 3.89 (Kjeldahl).

endo-3-Dimethylaminomethyl-α,α-diphenyl-5-norbornene-exo-2-methanol (VIII). A solution of phenyllithium was prepared by adding in portions under nitrogen 2.88 g. (0.146 g.-atom) of lithium wire to a solution of 32.8 g. (0.208 mole) of bromobenzene in 100 ml. of anhydrous ether. The mixture was stirred with a Hershberg stirrer until the reaction was complete. At the same time, the pure amino ketone VII was isolated by dissolving its fumarate in water, making the solution strongly basic with sodium hydroxide, extraction with ether, washing, drying, and concentration. A solution of 26.6 g. (0.104 mole) of *endo*-3-dimethylaminomethyl-5-norbornen-2-yl *exo*-phenyl ketone (VII) in 100 ml. of anhydrous ether was then added to the phenyllithium solution at a rate to maintain reflux (15 min.). The resulting reaction mixture was stirred at room temperature overnight and hydrolyzed by adding 33 ml. of water dropwise. When all of the solid had dissolved, the layers were separated and the aqueous part was extracted with ether. The combined ethereal solutions were washed with water, treated with charcoal, concentrated to dryness and the residue dried by distilling benzene from it. The product was 33.4 g. of VIII a brown gum; λ_{max}^{CCl4} 3.30 (—OH), 5.98 (very weak C=O), 6.26 μ (aromatic C=C).

Combination of 10.12 g. (0.034 mole) of this product with 3.54 g. (0.034 mole) of fumaric acid in isopropyl alcohol led to 9.13 g. (over-all 74%) of the fumarate, m.p. 212–214°. A sample of this salt, washed with hot ethanol, showed a m.p. of 214–215.5°; λ_{max}^{KBr} 3.25, 3.33, 4.14 (—OH), 6.28 μ (aromatic C=C). There was only benzene ring absorption in the ultraviolet spectrum above 210 mμ.

Anal. Calcd. for $(C_{23}H_{27}NO)_2 \cdot C_4H_4O_4$: C, 76.69; H, 7.47; N, 3.58. Found: C, 76.33, 76.41; H, 7.38, 7.66; N, 3.25, 3.51.

endo-3-Dimethylaminomethyl-α,α-diphenylnorbornane-exo-2-methanol (IX). A solution of 5.67 g. of the crude amino alcohol VIII from the previous experiment in 50 ml. of methanol was shaken under 3 atm. of hydrogen with 0.2 g. of 10% palladium-on-carbon for 3.5 hr. The catalyst was removed by filtration and the filtrate was concentrated to dryness under vacuum. The residue was dissolved in ether and extracted into dilute hydrochloric acid; the aqueous layer was made basic and extracted with ether. After drying over magnesium sulfate, the ether solution was treated with decolorizing carbon, filtered, and concentrated to dryness to give IX as a yellow gum (5.13 g.). From 0.26 g. of this base and 0.090 g. of fumaric acid in isopropyl alcohol–ether, there was obtained 0.26 g. of the hydrogen fumarate, m.p. 185–192°. Recrystallization from methanol-isopropyl alcohol–ether gave pure IX hydrogen fumarate, m.p. 191–192°; ultraviolet and infrared spectra consistent with structure.

Anal. Calcd. for $C_{23}H_{29}NO \cdot C_4H_4O_4$: C, 71.81; H, 7.37; N, 3.10. Found: C, 71.70; H, 7.52; N, 3.14.

endo-3-Dimethylaminomethyl-α-phenyl-α-o-tolyl-5-norbornene-exo-2-methanol (XI). A solution of *o*-tolyllithium was prepared from 6.45 g. (0.0375 mole) of *o*-bromotoluene and 0.52 g. (0.075 g.-atom) of lithium in 20 ml. of ether. This was treated with a solution of 4.78 g. (0.0187 mole) of amino ketone VII in 20 ml. of ether and worked up as described under the preparation of VIII. The product was 5.94 g. of a yellow oil; λ_{max}^{neat} 2.85, 3.29 (—OH), 6.25 μ (aromatic C=C).

From 3.16 g. of this product and 1.06 g. of fumaric acid in isopropyl alcohol–ether, there was obtained 2.37 g. (56%) of XI hydrogen fumarate melting at 174–189°; ultraviolet and infrared spectra consistent with structure.

A recrystallization of this material from isopropyl alcohol–ether gave a sample of XI hydrogen fumarate melting at 190.5–192.5° in about 50% recovery.

Anal. Calcd. for $C_{24}H_{29}NO \cdot C_4H_4O_4$: C, 72.54; H, 7.18; N, 3.02. Found: C, 72.28; H, 7.42; N, 3.07, 2.81.

McNeil Laboratories, Inc.
Fort Washington, Pa.

Carbamoylation of Some Cyclic 1,3-Dicarbonyl Compounds with Urea

Homer C. Scarborough

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The general class of tricarbonylmethane compounds contains examples with a wide variety of physiological actions as antifungal, anthelmintic, and antibacterial.[1] However, only the tetracycline incorporate a carbamoyl moiety as part of the tricarbonylmethane system. We wish to report a method of preparing 2-carbamoyl derivatives of some cyclic 1,3-dicarbonyl compounds through the use of readily accessible intermediates, *i.e.*, cyclic 1,3-dicarbonyl compounds and urea. The interest of others in such compounds has been disclosed using acetyl cyanate as an intermediate.[2]

Urea has found application as a source of the elements of cyanic acid as in the preparation of urethanes by reactions with alcohols and in the preparation of substituted ureas by reaction with amines.[3] The zinc chloride catalyzed carbamoylation of resorcinol under Friedel-Crafts conditions by means of urea has been reported.[4] Since organic acids catalyze the decomposition of urea, presumably *via* cyanic acid,[5] it was hoped that compounds

(1) C. H. Hassel, *Experimentia*, **6**, 642 (1950); C. H. Hassel in J. W. Cook, *Progress in Organic Chemistry*, vol. 4, 115, Academic Press, New York, 1958.

(2) M. M. Shemyakin, *et al.*, *Zhur. Obshchei Khim.*, **30**, 542 (1960).

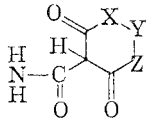
(3) R. B. Wagner and H. D. Zook, *Synthetic Organic Chemistry*, John Wiley & Sons, Inc., New York, 1953, p. 645.

(4) J. J. Roemer and W. M. Degnan, *J. Am. Chem. Soc.*, **63**, 103 (1941). According to these workers, the zinc chloride-urea method of carbamoylation is restricted to resorcinol.

(5) S. Ozaki, T. Mukaiyama, and K. Uno, *J. Am. Chem. Soc.*, **79**, 4358 (1947). T. Mukaiyama and T. Matsunaga, *J. Am. Chem. Soc.*, **75**, 6209 (1953).

such as 5,5-dimethyl-1,3-cyclohexanedione might furnish a proton for the catalytic decomposition of urea, with concurrent reaction of the anion with the cyanic acid to yield the carbamoyl derivative. The reaction of the anions of 1,3-diketones with alkyl or aryl isocyanates and isothiocyanates to furnish their 2-*N*-substituted carbamoyl and thiocarbamoyl derivatives has been reported.[6] The use of cyanic acid for the preparation of the desired primary amides did not appear attractive in view of its instability. Further, simple neutralization might occur in the reaction of 1,3-diketo salts with cyanic acid. When no basic catalyst was employed, 5,5-dimethyl-1,3-cyclohexanedione furnished the enolic carbamate with phenyl isocyanate.[6a]

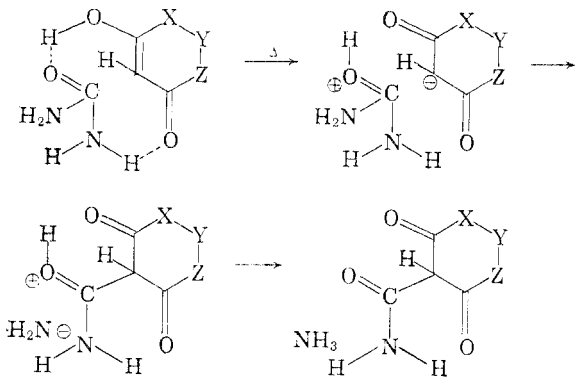
In the present work, urea was heated with 5,5-dimethyl - 1,3 - cyclohexanedione, 1,2 - diphenyl-3,5-pyrazolidinedione,[7] and 1 - phenyl - 3,5 - pyrazolidinedione[8] to furnish their carbamoyl derivatives (I, II, and III). All of the carbamoyl compounds were soluble in 0.1*N* sodium hydroxide and gave colored crystalline derivatives with cupric acetate. The pale blue copper derivative of I was stable to cold dilute sulfuric acid, but could be hydrolyzed to I at room temperature.[9]



Compound	X	Y	Z
I	CH_2	$(CH_3)_2C$	CH_2
II	C_6H_5N	C_6H_5N	—
III	C_6H_5N	HN	—

It is not necessary to postulate the existence of free cyanic acid at the elevated reaction temperatures which are required if the reaction is envisioned as proceeding through cyclic resonance stabilized transition states. We are investigating these possibilities further, using 2-substituted cyclic 1,3-dicarbonyl compounds and substituted ureas as intermediates.

Additional applications of the reaction are currently being investigated. The reaction is apparently limited to cyclic 1,3-dicarbonyl compounds since the urea adduct of 4,6-dimethyl-2-pyrimidol[10] was obtained by refluxing an aqueous



solution of acetylacetone and urea. The pyrimidine was characterized by conversion to the nitrate.[11]

EXPERIMENTAL[12]

2-Carbamoyl-5,5-dimethyl-1,3-cyclohexanedione (I). A mixture of 20 g. (0.15 mole) of 5,5-dimethyl-1,3-cyclohexanedione and 18 g. (0.3 mole) of urea was heated at 137° for 20 min. The cooled mixture was dissolved in 150 ml. of hot methanol, the solution treated with Nuchar brand activated charcoal, and 250 ml. of 0.1*N* hydrochloric acid added. Cooling gave 9 g. (33%) of white crystalline solid, m.p. 139–143°. Recrystallizations from methanol and from ethyl acetate furnished 8 g. (30%), m.p. 145–146°. A solution in 0.1*N* sodium hydroxide exhibited maxima in mμ in the ultraviolet at 272 (ϵ = 14,120); in 0.1*N* hydrochloric acid at 260 (ϵ = 15,790).

Anal. Calcd. for $C_9H_{13}NO_3$: C, 59.00; H, 7.15; N, 7.65. Found: C, 58.82; H, 7.11; N, 7.47.

The pale blue *copper salt* was obtained by the addition of methanolic cupric acetate to a solution of I in methanol. The copper salt did not melt and was insoluble in organic solvents. The salt could be hydrolyzed by stirring with 10% sulfuric acid and ether at room temperature for 2 hr. The ether was separated and the aqueous phase washed with ether. The combined ethereal solutions were washed with water, dried with magnesium sulfate and concentrated to yield I, m.p. 145–146°.

4-Carbamoyl-1,2-diphenyl-3,5-pyrazolidinedione (II). A mixture of 16 g. (0.064 mole) of 1,2-diphenyl-3,5-pyrazolidinedione[4] and 7.6 g. (0.126 mole) of urea contained in a 100-ml. round bottom flask was heated in an oil bath at 150° for 10 min. and at 145° for an additional 10 min. with intermittent hand stirring. The glass obtained upon cooling was dissolved with heat in 50 ml. of methanol and then 300 ml. of water was added. The solution was concentrated to about two-thirds volume and then diluted to 300 ml. with water. After washing with two 40-ml. portions of ethyl acetate the solution was acidified to *p*H 2 with hydrochloric acid. The precipitated product was collected, dried, and suspended in 120 ml. of butanone. The insoluble portion was separated and the liquor concentrated to 30 ml. The solution was diluted with heptane to 220 ml. and chilled to furnish 13 g., m.p. 144–147°. Recrystallization from 60 ml. of methanol gave 11 g. (59%), m.p. 154–156°; in 0.1*N* sodium hydroxide, λ_{max} 243 mμ (ϵ = 31,200). In 50% aqueous ethanol, the half neutralization point was at *p*H 3.0.

Anal. Calcd. for $C_{16}H_{13}N_3O_3$: C, 65.08; H, 4.44; N, 14.23. Found: C, 65.29; H, 4.46; N, 13.93.

4-Carbamoyl-1-phenyl-3,5-pyrazolidinedione (III). A mixture of 3.5 g. (0.02 mole) of 1-phenyl-3,5-pyrazolidinedione[4]

(6) (a) W. Dieckmann, J. Hoppe, and R. Stein, *Ber.*, **37**, 4635 (1904). (b) S. Ruhemann, *J. Chem. Soc.*, **93**, 621 (1908). (c) D. E. Worall, *J. Am. Chem. Soc.*, **50**, 1456 (1928); *J. Am. Chem. Soc.*, **42**, 1055 (1920).

(7) H. Ruhkopf, *Ber.*, **73**, 820 (1940).

(8) M. Conrad and A. Zart, *Ber.*, **39**, 2283 (1906).

(9) The pale blue copper salt of C-acetyldimedon is hydrolyzed in dilute sulfuric acid at 0°. See W. Dieckmann and R. Stein, *Ber.*, **37**, 3370 (1904).

(10) S. Birtwell, *J. Chem. Soc.*, 1725 (1953).

(11) T. deHoan, *Rec. trav. chim.*, **27**, 162 (1908); *J. Chem. Soc.*, **94i**, 577 (1908).

(12) All melting points are uncorrected. Microanalyses by Spang Microanalytical Laboratory, Ann Arbor, Mich.

and 2.4 g. (0.04 mole) of urea was heated at 150° for 12 min. to yield a glass which was boiled with 50 ml. of water. Cooling gave a gelatinous material which was discarded. The liquor, *p*H 4, was acidified to *p*H 1 with hydrochloric acid to precipitate a heavy solid which was collected and then stirred with 150 ml. of methanol for 1.5 hr. After separation of a small amount of insoluble material, the methanol solution was concentrated to dryness and the residue suspended in butanone. A little insoluble material was removed and the liquor diluted with heptane to furnish a solid which was collected, dried and recrystallized from water and from butanone to furnish 1 g. (23%), m.p. 186–191°. The melting point varied with the rate of heat; however, the product showed good depression with 1-phenyl-3,5-pyrazolidinedione; in 0.1*N* sodium hydroxide, λ_{max} 290 (shoulder) and 256 mμ (ϵ = 4710 and 12,600).

Anal. Calcd. for $C_{10}H_8N_2O_3$: C, 54.79; H, 4.14; N, 19.17. Found: C, 54.46; H, 4.16; N, 19.20.

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DEPARTMENT OF SYNTHETIC ORGANIC CHEMISTRY
MEAD JOHNSON AND CO.
EVANSVILLE 21, IND.

Adducts of Halogenated Cyclopentadienes with Halogenated Quinones[1,2]

HENRY RAKOFF AND BRAD H. MILES[3]

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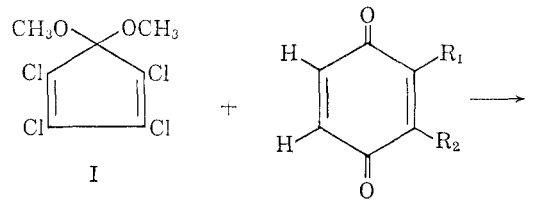
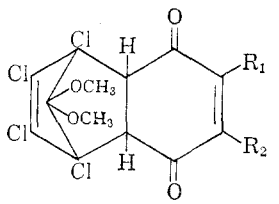
The use of tetrachloro-substituted, conjugated, alicyclic dienes as reactants in the Diels-Alder Reaction has been known for some time. 1,2,3,4-Tetrachloro-1,3-cyclopentadiene,[4] tetrachlorocyclopentadienone,[5] and 5,5-dimethoxy-1,2,3,4-tetrachloro-1,3-cyclopentadiene (I)[6] are all known to undergo this reaction.

McBee, Diveley, and Burch[6] describe a method for preparing aromatic compounds by a sequence of reactions involving hydrolysis of the ketal and removal of the carbonyl bridge from adducts between I and various dienophiles. It was hoped that this sequence could be applied to the synthesis of chlorinated naphthoquinones. While this desire was not realized, some novel information on the chemical behavior of the adducts between I and chlorinated quinones was obtained.

The diene (I) was treated with *p*-benzoquinone, monochloroquinone, and 2,3-dichloroquinone to yield the expected adducts (II–IV). Attempts to react I with 2,5-dichloroquinone or with chloranil were unsuccessful.

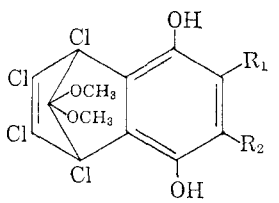


I



II. $R_1 = R_2 = H$
III. $R_1 = H$; $R_2 = Cl$
IV. $R_1 = R_2 = Cl$

Attempts to hydrolyze the adducts to the carbonyl bridge compounds with sulfuric acid gave either no reaction or highly colored, pasty materials depending upon the concentration of the acid employed. Attempted hydrolysis of II with an acetic acid-hydrochloric acid mixture converted it to its enol isomer (V). Adducts III and IV were isomerized to their enol isomers, VI and VII, by refluxing the respective adducts in methyl alcohol containing pyridine.[7]



V. $R_1 = R_2 = H$
VI. $R_1 = H$; $R_2 = Cl$
VII. $R_1 = R_2 = Cl$

The diacetates and dibenzoates of enol isomers V, VI, and VII and the diethyl ethers of V and VI were prepared according to standard procedures.

The reaction of II with stannous chloride and hydrochloric acid resulted in reduction of the double bond in the quinone portion of the molecule. The carbonyl groups were not reduced, but the yellow color of the quinone was lost leaving the white compound VIII. The infrared spectrum of this compound is consistent with the presence of carbonyl groups and the absence of hydroxy groups. In addition, VIII reacted with 2,4-dinitrophenylhydrazine to form a bright yellow, bis-2,4-dinitrophenylhydrazone. The reduction of III or IV with

(1) A portion of this work is taken from the M.S. thesis of Brad H. Miles.

(2) A portion of this work was presented before the Southwest Regional Meeting of the American Chemical Society. San Antonio, Tex., Dec., 1958.

(3) Present address: Dow Chemical Company, Freeport, Tex.

(4) E. T. McBee, R. K. Meyers, and C. F. Baranauckas, *J. Am. Chem. Soc.*, **77**, 86 (1955).

(5) J. S. Newcomer and E. T. McBee, *J. Am. Chem. Soc.*, **71**, 948 (1949).

(6) E. T. McBee, W. R. Diveley, and J. E. Burch, *J. Am. Chem. Soc.*, **77**, 385 (1955).

(7) E. Segel, R. E. Lidov, and J. Hyman, U. S. Pat. **2,584,140** (Feb. 5, 1952); *Chem. Abstr.*, **46**, 9591i (1952).