4-Hydroxy-2'-mercapto-3-chloro-2,4',6'-trimethoxy-6-methylbenzophenone Diacetate (11).—A mixture of 4.4 g (0.018 mol) of **9** (above) and 4.0 g (0.018 mol) of isoeverninic acid acetate (**10**)[8,9] in 60 ml of trifluoroacetic anhydride was heated in a pressure bottle at 55–60° for 20 hr. The dark solution was evaporated *in vacuo*, the residue dissolved in methylene chloride, and the solution washed with aqueous bicarbonate, dried, and evaporated to yield a gummy residue which solidified on trituration with ether. The purple tinged colorless solid obtained, 2.8 g (34%), melted at 163–166°. Heating, partially dissolved, in boiling methanol furnished the analytical sample: mp 168–170°; λ_{max}^{Nujol} 5.67 (OAc), 5.87 (thioacetate), and 6.00 μ (ArCOAr); λ_{max}^{MeOH} 311 mμ (ϵ 7720), 242 sh (17,000), and 209 (50,000).

Anal. Calcd for $C_{21}H_{21}ClO_7S$ (452.91): C, 55.69; H, 4.67; S, 7.08. Found: C, 55.94; H, 5.09; S, 7.06.

Only partial conversion into **11** was realized when the reaction was conducted at room temperature.[13]

4'-Hydroxy-2-mercapto-3-chloro-2',4,6-trimethoxy-6'-methylbenzophenone (4).—Nitrogen was bubbled through a stirred suspension of 2.5 g (0.055 mol) of **11** in 40 ml of methanol at room temperature and 40 ml of 2 *N* aqueous sodium hydroxide was added in *ca.* 3 min. By the end of 10–15 min the reaction mixture was homogeneous. The nitrogen passage was terminated, and the flask stoppered and kept at room temperature for an additional 1.25 hr. Ice was added to the solution which was then acidified with cold, fairly concentrated hydrochloric acid. The practically colorless gum which separated solidified almost immediately and was collected after 15 min and air dried overnight; yield 2 g (99%); mp 195–199°. Recrystallization from aqueous methanol furnished the analytical sample: mp 198–199; λ_{max}^{Nujol} 290 and 6.33 μ. The latter band showed two inflections at 6.13 and 6.23 μ: λ_{max}^{MeOH} 300 mμ (ϵ 9250), 240 sh (21,300), and 210 (40,800).

Anal. Calcd for $C_{17}H_{17}ClO_5S$ (368.78): C, 55.36; H, 4.65; S, 8.70. Found: C, 55.05; H, 4.83; S, 8.43.

7-Chloro-2',4,6-trimethoxy-6'-methylspiro[benzo(*b*)thiophene-2(3H),1'-(2,5)-cyclohexadiene]-3,4'-dione (5).—A solution of 1.7 g (0.0046 mol) of **4** (above) in 150 ml of water containing 25 g of potassium carbonate was added dropwise, over *ca.* a 10-min period, to a stirred solution of 6 g (0.018 mol) of potassium ferricyanide in 75 ml of water. The solid which began separating almost immediately was collected after stirring for 1 additional hr and heated, suspended, in boiling ethanol: yield 1.3 g (77%); mp 235–238°. A portion of this product was again heated in boiling ethanol to furnish the analytical sample: mp 236–238°; λ_{max}^{Nujol} 5.90 and 6.02 μ; λ_{max}^{MeOH} 348 mμ (ϵ 4550), 306 (18.700) and 235 (43,300). The nmr spectrum is presented in Table I.

Anal. Calcd for $C_{17}H_{15}ClO_5S$ (366.82): C, 55.66; H, 4.12; Cl, 9.67; S, 8.74. Found: C, 55.66; H, 4.41; Cl, 9.84; S, 863.

Attempted Reduction of 5 to the Ring-B Sulfur Analog of Griseofulvin.—A solution of 0.2 g (0.54 mmol) of **5** in a minimum of methylene chloride was prepared and diluted with 25 ml of ethyl acetate. The resulting solution was added to a suspension of 0.4 g of prereduced 10% Pd–C (prepared according to the procedure in ref 14) in 5 ml of ethyl acetate and the mixture was stirred under hydrogen at room temperature and atmospheric pressure until 10 ml of hydrogen was consumed (30 min) (0.54 mmol = 13.3 ml of H_2). The catalyst was separated by filtration through Celite and the filtrate evaporated to yield 0.18 g of a light yellow opaque gum which was separated into a base-soluble and base-insoluble fraction by dissolving in methylene chloride and extracting with cold dilute sodium hydroxide. The nmr spectrum of the base-insoluble fraction [isolated by drying and evaporating the methylene chloride solution (0.12 g, mp 237–240°)] was identical with that of pure **5**. The base-soluble material [obtained by acidifying the dilute sodium hydroxide extract and collecting the solid which separated (45 mg, mp 194–197°)] was identified by ir and thin layer chromatography as benzophenone **4**.

(13) As might have been anticipated, **8** proved more reactive. It was acylated by **10** in trifluoroacetic anhydride at a reasonable rate at room temperature.

(14) "Organic Syntheses, Coll. Vol. III, John Wiley & Sons, Inc., New York, N. Y., 1955, p 687. (Darco-G-60 was the support employed.)

Registry No.—**4**, 19689-64-6; **5**, 19689-65-7; **7**, 19689-66-8; **8**, 19689-67-9; **9**, 19689-68-0; **11**, 19689-69-1.

Acknowledgment.—We thank Mr. L. Brancone and staff for the microanalyses and Mr. W. Fulmor and staff for the ultraviolet and nmr spectra.

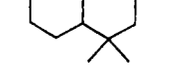
A 1,4-Pyran Compound from Condensation of Pulegone and Ethyl Acetoacetate

Y. L. CHOW AND H. H. QUON

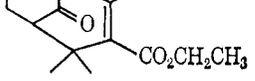
Department of Chemistry, Simon Fraser University, Burnaby 2, British Columbia, Canada

Received November 14, 1968

The zinc chloride catalyzed condensation of pulegone[1,2] with ethyl acetoacetate has been reported to yield two major crystalline compounds having mp 74–76°, proved[1,3] to possess structure **1**, and mp 37–39°, respectively.[1] Bicyclo[3.3.1]nonenone **2** was proposed as a possible structure for the compound of mp 37–39° in our early communication.[4] New chemical evidence and spectroscopic data now confirm that the compound of mp 37–39° is 2,4,4,7-tetramethyl-3-carbethoxy-5,6,7,8-tetrahydrobenzopyran[5] (**3**).



1



2

In our earlier condensation experiments it was noticed that although the yield of enone **1** did not fluctuate appreciably, the yield of pyran ester **3** varied from 12 to 0% depending on the conditions of the condensation. It was shown that a prolonged heating of the reaction eventually gave only enone **1** and no pyran ester **3**. Shorter reaction time or milder reaction conditions did not improve the yield of pyran ester **3**, but also resulted in recovery of a substantial amount of the starting material. Under the condensation conditions pyran ester **3** was gradually rearranged to enone **1**. Pyran ester **3** is, therefore, formed by a kinetically controlled process and reversibly rearranges to the thermodynamically more stable enone **1**.

Elemental analysis and mass spectroscopy established the molecular formula of the compound of mp 37–39° as $C_{16}H_{24}O_3$. In the absence of a deep-seated rearrangement, two structures **2** and **3** can be formulated for the compound of mp 37–39°. The chemical transformations summarized in Scheme I would

(1) Y. L. Chow, *Acta Chem. Scand.*, **16**, 205 (1962).

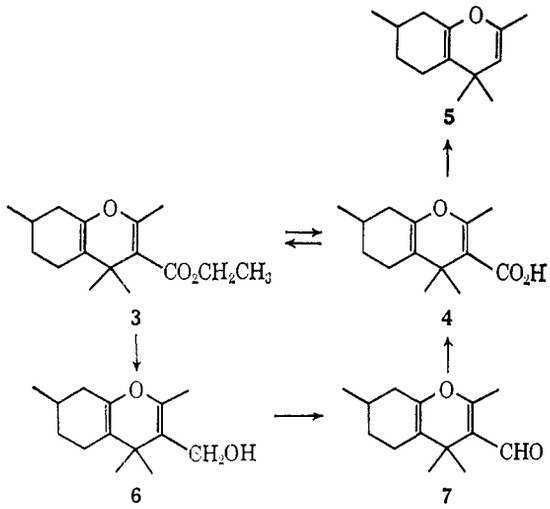
(2) P. Barbier, *C. R. Acad. Sci., Paris*, **127**, 870 (1898); L. G. Jupp, G. A. R. Kon, and E. H. Lockton, *J. Chem. Soc.*, 1639 (1928).

(3) J. Wolinsky and M. A. Tyrell, *Chem. Ind.* (London), 1104 (1960).

(4) Y. L. Chow, *Tetrahedron Lett.*, 1337 (1964).

(5) Professor J. Wolinsky has independently proved that the compound of mp 37–39° has structure **3**. We thank Professor Wolinsky for calling our attention to his paper [J. Wolinsky and H. S. Hauer, *J. Org. Chem.*, **34**, 380 (1969); Abstract, 155th National Meeting of the American Chemical Society, San Francisco, Calif., April 1968].

SCHEME I

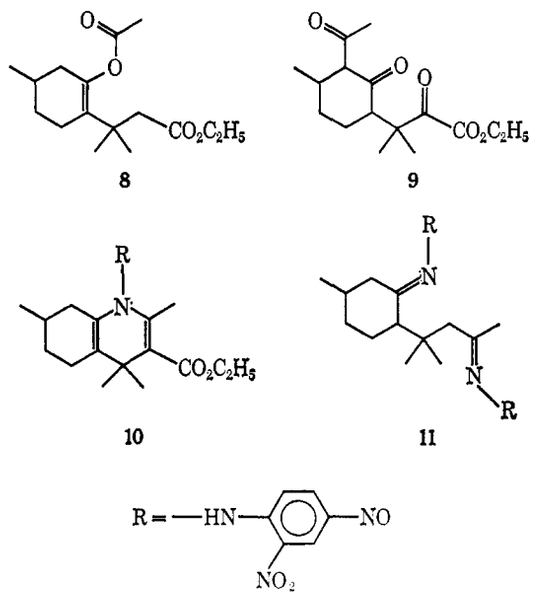


eliminate structure **2** but do not unambiguously prove the correctness of pyran structure **3**.

The primary aim of the chemical transformations (Scheme I) was to remove the conjugated carbethoxy group from parent compound **3** in order to simplify the chromophore system. The hindered nature of the ester grouping in **3** was indicated by the observation that **3**, after being vigorously refluxed in ethanolic potassium hydroxide solution, was only partially hydrolyzed to acid **4**. The carboxylic acid was re-esterified to **3** proving that no skeletal rearrangement had occurred during the vigorous base treatment. Carboxylic acid **4** was decarboxylated in hot quinoline to give pyran **5** which showed one olefinic proton at abnormally high field[6-9] at τ 5.82 (quartet) in the nmr spectrum and intense ir absorption at 1715 cm^{-1}. Vigorous treatment of **3** in ether with lithium aluminium hydride gave alcohol **6**. Although survival of a carbonyl group was unlikely under the reduction conditions, alcohol **6** showed the intense ir absorption at 1710 cm^{-1} and ultraviolet maxima at 235 and 285 mμ. While alcohol **6** could be oxidized by Sarett reagent in good yield to aldehyde **7**, the latter was converted into carboxylic acid **4** only by air oxidation, but not by other oxidizing agents.

The best proof that a carbonyl was absent in **5** and **6** came from the ORD curves[10] of these two compounds which exhibited plain positive curves regardless of the determination in isooctane or in ethanol. This argument was further supported by the failure of the deuterium incorporation into the carboxylic acid **4** in a basic condition. A literature search reveals that a 1,4-pyran usually exhibits fairly intense infrared absorption at about 1710- and 1660-cm^{-1} regions.[7,9,11] However, the ultraviolet maxima shown by **3**–**6** cannot be readily reconciled with the pyranoid structure since no data of a good model system can be found. Uptake of 2 mol equiv of hydrogen under vigorous hydrogenation finally proved that the compound of mp 37–39° contained two olefinic bonds (which must be tetrasubstituted) and therefore should be represented by **3**.

An unambiguous proof of pyran **3** was secured by ozonolysis of the conjugated double bond followed by mild reductive decomposition in which the probability of a skeletal rearrangement could be kept to a minimum. The expected ozonolysis products from structures **3** and **2** were **8** and **9**, respectively, wherein substantial



structural differences were obvious. The major component from this cleavage reaction, though obtained in only 18% yield, was shown to be **8** by spectroscopic data. The infrared absorption at 1750 and 1180 cm^{-1} and the strong mass peaks at 237 (corresponding to $M^+ - CH_3CO_2$) prove the presence of a vinyl acetate group. The ultraviolet[12] and the nmr[13] spectra do not show a maximum at the 250-mμ region nor a signal at low field typical for a 1,3 diketone. Thus the compound of mp 37–39° is proven to be pyran ester **3**.

The mass spectrum of pyran ester **3** shows the dominant peak at *m/e* 249 equivalent to $M^+ - 15$. The driving force for the tendency to loose a methyl group (from *gem*-dimethyl) is no doubt provided by the aromatization to a pyrylium ion. Elimination of either C_2H_4 (*m/e* 221) or C_2H_5OH (*m/e* 203) species from the pyrylium ion are readily conceivable *via* a similar transition state proposed in McLafferty rearrangement.[14]

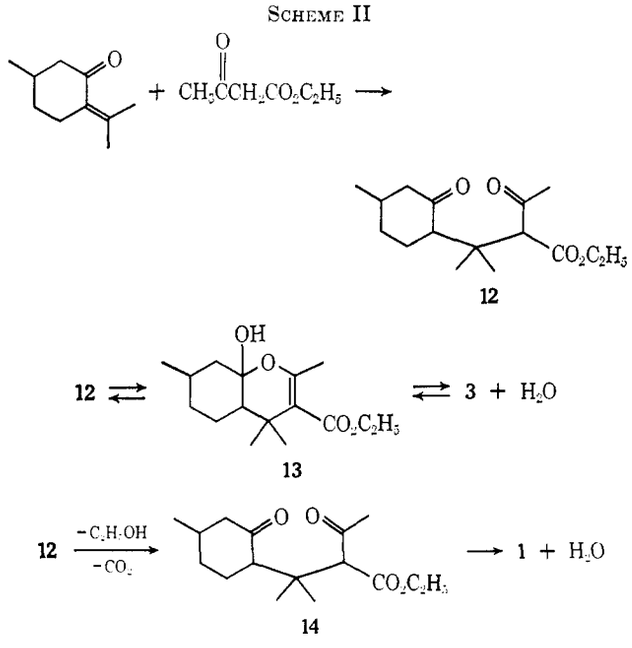
It is now in order to comment on the products obtained from the reaction of 2,4-dinitrophenylhydrazine with pyran ester **3** and pyran **5**. On treatment of pyran ester **3** with Brady's reagents, beautifully crimson needles were obtained which exhibited an ultraviolet maximum at 325 mμ. Since the nmr spectrum of the needles retained the typical ethyl signals of the carbethoxy group, the derivative was obviously not the corresponding acyl 2,4-dinitrophenylazide as pro-

(6) J. Feeney, A. Ledwith, and L. H. Sutcliffe, *J. Chem. Soc.*, 2021 (1962).
(7) S. Masamune and N. T. Castellucci, *J. Amer. Chem. Soc.*, **84**, 2452 (1962).
(8) "NMR Spectra Catalog," Varian Associates, Palo Alto, Calif., 1962, No. 111.
(9) H. W. Whitlock, Jr., and N. A. Carlson, *Tetrahedron*, **20**, 2101 (1964).
(10) C. Djerassi, "Optical Rotatory Dispersion," McGraw-Hill Book Co., Inc., New York, N. Y., 1960.
(11) M. J. Jorgenson, *J. Org. Chem.*, **27**, 3224 (1962).
(12) Most of the 1,3-diketones show an intense absorption at 250–270 mμ (ϵ 10,000) region in an alcoholic solution obviously due to enolization [E. G. Meek, J. H. Turnbull, and W. Wilson, *J. Chem. Soc.*, 2891 (1953)].
(13) L. M. Jackman "Application of NMR Spectroscopy in Organic Chemistry," Pergamon Press, London, 1959, p 70.
(14) R. M. Silverstein and G. C. Bassler, "Spectrometric Identification of Organic Compounds," 2nd ed, John Wiley & Sons, Inc., New York, N. Y., 1967, p 22.

posed previously.[4] On the other hand, the ultraviolet maximum of the needles is very similar to the maxima of diethyl 1-(2′,4′-dinitrophenylamino)pyrrole 3,4-dicarboxylate.[15] Dihydropyridine **10** is, therefore, assigned to the crimson needles. Although the purity of dihydropyridine **10** was fully established by tlc analysis,[16] the nmr signal of the *gem*-dimethyl group displays many sharp singlets and that of vinylic methyl a closely located doublet. In pyridine solution **10** showed singlets (τ 8.01 and 8.60) for vinylic methyl and one of the *gem*-dimethyl groups and a doublet (τ 8.46) for the other *gem*-dimethyl group. The latter doublet did not collapse when the temperature was raised to 100°. Interaction of Brady's reagent with pyran **5** readily gave yellow crystals analyzed as $C_{25}H_{30}N_8O_8$. The ultraviolet absorption of 361 mμ (ϵ 30,100) displayed by this compound demonstrated the presence of two 2,4-dinitrophenylhydrazone groups. Under the reaction conditions the hydrolysis of pyran **5** to the corresponding diketone was apparently possible. The yellow crystals are, therefore the bishydrazone (**11**).

It is now possible to suggest a mechanism of condensation of pulegone with the acetoacetate as shown in Scheme II. The formation of pyran ester **3** *via* **12** and **13** may be facilitated by the presence of the hindered carbethoxyl group which promotes the enolization of **12** and eventually the pyran ring closure. A steric acceleration of the pyran ring closure may also be suggested by the presence of the methyl and carbethoxyl substitutions. As soon as the carbethoxyl group is eliminated, such effects are no longer present in **14** and enone **1** is formed.

SCHEME II



Experimental Section[17]

Condensation of Pulegone and Ethyl Acetoacetate.—A solution consisting of pulegone (Fluka AG., $[\alpha]_D$ +22.1, 150 g), ethyl acetoacetate (137 g), freshly fused zinc chloride (150 g), and glacial acetic acid (500 g) was heated over a water bath for 5 hr. The reaction mixture was poured into ice water (1.5 l.) and the oil was extracted with ether. The ether extract was washed with water and dried to afford a residue (145 g) after evaporation. The residue was subjected to fractional distillation under 10 mm vacuum. The forerun (35 g, bp up to 102°) was the recovered starting material. The second fraction (56 g, bp 102–130°) solidified on standing and was shown to contain mostly enone **1**.

The third fraction (39 g, bp 130–144°) partially crystallized on standing. A part of the crystals (1 g) was chromatographed on an alumina column. Elution with light petroleum gave a crystalline fraction (830 mg) which was recrystallized from light petroleum three times to afford an analytical sample of the pyran ester **3**: mp 37–39°; $[\alpha]_D$ +47.8 (in EtOH); λ_{max} 206 mμ (ϵ 5900) and 272 (2500). The uv absorption of **3** is not appreciably changed in 5% NaOEt solution. Compound **3** has the infrared absorption at 1712, 1635, 1310, 1170, and 1050 cm^{-1}; the nmr signals (CCl_4) at τ 5.89 (q, J = 7 Hz, 2 H), 8.10 (s, 3 H), 8.72 (t, J = 7 Hz, 3 H), 8.77 (s, 3 H), 8.80 (s, 3 H), and 9.03 (d, J = 5 Hz, 3 H).

Anal. Calcd for $C_{16}H_{24}O_3$: C, 72.69; H, 9.15. Found: C, 72.74; H, 8.93.

The yields of pyran ester **3** and enone **1** varied considerably depending on the experimental conditions and were usually poorer than that shown above. Pyran ester **3** consumed bromine in carbon tetrachloride and exhibited red color with tetranitromethane. Pyran ester **3** showed negative for iodoform test and semicarbazone formation and was stable toward a hot 10% ethanolic potassium hydroxide solution for several hours.

Reaction of Pyran Ester 3 with 2,4-Dinitrophenylhydrazine.—To a solution of **3** (106 mg) in ethanol (4 ml) was added Brady's reagent (5 ml). Red needles precipitated slowly and were recrystallized three times from ethanol to give a crimson crystal (176 mg): mp 182–184°; λ_{max} 326 mμ (ϵ 17,700); the ir absorptions at 3320, 1700, 1618, 1592, 1534, 1515, 1500 and 1335 cm^{-1}; and the nmr signals at τ 0.90 (d, J = 2.5 Hz, 1 H), 1.65 (d of d, J = 2.5 and 10 Hz, 1 H), 2.70 (m, 3 H), 5.78 (q, J = 7 Hz, 2 H), 8.69 (t, J = 7 Hz, 3 H), and 9.10 (d, J = 5 Hz, 3 H). At room temperature, the $=CCH_3$ protons (τ 8.17) showed an unequal doublet and the CH_3CCH_3 protons (τ 8.7) an irregular multiplet.

Anal. Calcd for $C_{22}H_{28}N_4O_6$: C, 59.44; H, 6.35; N, 12.61. Found: C, 59.14; H, 6.22; N, 12.53.

Acid-Catalyzed Isomerization of the Pyran.—A solution of pyran ester **3** (570 mg), fused zinc chloride (500 mg), and glacial acetic acid (10 ml) was heated over a water bath for 15 hr. The reaction mixture was worked in the usual manner to afford enone **1** (85 mg), mp and mmp 74–76° with an authentic sample[1].

Carboxylic Acid 4.—The pyran ester **3** (300 mg) and potassium hydroxide (1.5 g) in ethanol (10 ml) were vigorously refluxed for 30 hr. The hydrolysate was worked up in a usual manner to give unreacted starting material (60 mg) and a crystalline acidic fraction (190 mg). The acidic fraction was recrystallized from chloroform and then from ethanol to afford the carboxylic acid **4**: mp 205–206° (evolution of gas on melting in a sealed tube); $[\alpha]_D$ +61° (in EtOH); λ_{max} 209 mμ (ϵ 6500) and 270 (2600). The carboxylic acid shows the ir absorption ($CHCl_3$) at 2300–3500, 1710, 1685, 1620, and 1320 cm^{-1} and the nmr signals at τ 7.94 (s, 3 H), 8.67 (s, 6 H), and 9.04 (d, J = 5 Hz, 3 H). In a DMSO solution the *gem*-dimethyl groups show two singlets at τ 8.67 and 8.68. The mass spectrum of the acid shows peaks at m/e 236 (2) 221 (94), 203 (5), 192 (5), 177 (100).

Anal. Calcd for $C_{14}H_{20}O_3$: C, 71.16; H, 8.53. Found: C, 70.90; H, 8.41.

The carboxylic acid (130 mg) was treated successively with sulfonyl chloride (5 ml) at room temperature and then with ethanol in the presence of pyridine to give an oil. This oil was chromatographed on alumina (5 g) to give a crystalline fraction

(15) T. D. Binns and R. Brettle, *J. Chem. Soc.*, *C*, 341 (1966).

(16) The original 2,4-DNP derivatives were further purified to give mp 182–184°.

(17) Unless specified otherwise the following experimental conditions prevail. The nmr spectra were recorded in $CDCl_3$ solution with respect to an internal TMS reference with the Varian Associates A-60 spectrometer. The mass spectra were measured with an Hitachi-Perkin Elmer RMU-6E mass spectrometer at ionization voltage 80 eV. The ultraviolet spectra were recorded in 95% ethanol with a Cary 14 spectrophotometer and the infrared spectra in Nujol mull or liquid film with Perkin-Elmer Model 421 and 457. The ORD curve was measured with a Rudolph spectropolorimeter. All melting points are uncorrected. The elemental analyses were performed by Dr. A. Bernhardt, West Germany. The splitting patterns of the nmr spectra are expressed by s (singlet), d (doublet), t (triplet), q (quartet), and the number of hydrogen by H.

(125 mg) which was recrystallized from ethanol to afford pyran ester **3**, mp and mmp 37–39°.

A clean piece of sodium (350 mg) was dissolved in D_2O (5 ml). The carboxylic acid (226 mg) was dissolved in the solution and was refluxed for 3 hr under nitrogen atmosphere. Acetic anhydride was added dropwise until pH ~6. The precipitate was recrystallized from ethanol three times to afford the carboxylic acid, mp 205–206°. The infrared and mass spectra of this sample were completely indistinguishable from those of an authentic sample of carboxylic acid **4**.

Decarboxylation of the Carboxylic Acid.—A solution of the carboxylic acid (870 mg) in redistilled quinoline (20 ml) was refluxed for 1 hr. Upon a usual working up, the unreacted carboxylic acid (370 mg) and a neutral oil (310 mg) were obtained. The oil was recrystallized from ethanol–water (5:1) three times to give pyran **5**; mp 32.7–33.5° (sealed tube); $[\alpha]_D$ +63.9 (in EtOH); λ_{max} 221 mμ (ε 4600), 230 (2770), 275 (157), 286 (142), 303 (36), and 318 (21) in cyclohexane. The crystalline compound of **5** sublimed quickly on exposure to the air and gave red color with tetranitromethane in CCl_4. Pyran **5** shows their absorptions at 1715, 1678, and 812 cm^{-1}; nmr τ 9.03 (d, J = 4 Hz, 3 H), 8.96 (s, 6 H), 8.32 (d, 1 Hz, 3 H), 5.82 (q, J = 1 Hz, 1 H); plain positive ORD curve φ (mμ) 32 (550), 41 (500), 50 (450), 70 (400), 95 (350) and 160 (300) in ethanol and 70 (550), 95 (500), 119 (450), 155 (400), 234 (350) and 415 (300) in isooctane.

Anal. Calcd for $C_{13}H_{20}O$: C, 81.20; H, 10.48. Found: C, 81.32; H, 10.48.

On treatment with Brady's reagent, pyran **5** gave a yellow precipitate which was recrystallized from ethanol–ethyl acetate three times to afford bishydrazone **11**: mp 184–186°; λ_{max} 229 mμ (ε 23,300), 260 (15,700), and 361 (30,100). The molecular weight determination by Rast method was 601.

Anal. Calcd for $C_{25}H_{30}N_8O_8$: C, 52.65; H, 5.35; N, 19.67. Found: C, 52.46; H, 5.30; N, 19.47.

Reaction of Pyran Ester 3 with $LiAlH_4$.—Pyran **3** was recovered unchanged on treatment with potassium borohydride in aqueous methanol solution overnight. A solution of **3** (850 mg) and lithium aluminum hydride (700 mg) in dry ether (100 ml) were refluxed for 5 hr. The reaction mixture was decomposed with ethyl acetate and was further treated with 20% ammonium hydroxide solution. The product was extracted with light petroleum in the usual manner to give a residue which was recrystallized from light petroleum several times to afford alcohol **6** (425 mg): mp 80–82.5°; $[\alpha]_D$ +62.5 (EtOH); λ_{max} 235 mμ (ε 2660), 285 (20), and 300 (10). Alcohol **6** exhibits the ir absorption (CCl_4) at 3640, 3520, 1710, 1665, and 1195 cm^{-1}; nmr signals at τ 5.82 (s, 2 H), 4.8 (broad, 1 H), 8.09 (s, 3 H), 8.85 (s, 6 H) and 9.02 (d, J = 5 Hz, 3 H); and a plain positive ORD curve of φ (mμ) 102 (550), 130 (500), 165 (450), 222 (400), 335 (350), 585 (300) and 850 (280) in ethanol and 105 (550), 130 (500), 170 (450), 225 (400), 340 (350), 655 (300), and 940 (280) in isooctane.

Anal. Calcd for $C_{14}H_{22}O_2$: C, 75.63; H, 9.97; active H, 0.45. Found: C, 75.60; H, 9.76; active H, 0.40.

Although alcohol **6** was recovered unchanged on treatment in hot 1 *N* ethanolic sodium hydroxide solution, it decomposed on storage or on treatment in ethanol solution containing a trace of hydrochlorice acid. Amorphous precipitates were obtained on attempts to prepare 2,4-DNPH, semicarbazone, and thiosemicarbazone.

The acetate of alcohol **5** was formed (acetic anhydride–pridine) as an oil which showed the infrared absorption at 1740, 1715, 1670, 1235, and 1220 cm^{-1} and the nmr signals at τ 5.40 (s, 2 H), 8.02 (s, 3 H), 8.17 (s, 3 H), and 8.9 (s, 6 H).

Oxidation of Alcohol 6.—A solution of the alcohol (1 g) in pyridine (30 ml) was oxidized with a chromic oxide (900 mg) solution in pyridine (5 ml) overnight at 0–5°. After the usual working up, an oil (780 mg) was obtained as the neutral fraction but no material could be obtained from sodium hydroxide (2 *N*) extraction. This oil showed their peaks at 2750, 1712, and 1615 cm^{-1} and was oxidized with a slow stream of air in ethanol (100 ml) for several days. The solvent was evaporated and the remaining residue was triturated with light petroleum to give a crystalline precipitate (145 mg). The crystals were recrystallized from ethanol to give the carboxylic acid **4**. The oil remained from the isolation of the carboxylic acid was oxidized with air in the similar manner to give additional amounts of carboxylic acid **4**.

Hydrogenation of Pyran Ester 3.—A preliminary experiment showed that pyran ester **3** did not absorb hydrogen in ethanol in the presence of palladized carbon (10%) over 48-hr period. Pyran ester **3** (80 mg) platinum oxide (30 mg) in glacial acetic acid (10 ml) were hydrogenated at atmospheric pressure for 20 hr at room temperature. The product was isolated in the usual manner to give an oil. This oil was taken up in light petroleum and percolated through an alumina column to give a colorless oil which was distilled from bulb to bulb under 10 mm pressure. The distillate showed the infrared absorption at 1735 and 1715 cm^{-1} (medium) and, in the nmr region, complex multiplet at τ 5.85–6.75 and many singlets at 9.1–8.7. The mass spectrum showed the intense M^+ peak at 268.

Ozonolysis of Pyran Ester 3.—A solution of **3** (789 mg) in chloroform (30 ml) was ozonized at 0° for 15 min followed by a zinc dust decomposition.

The neutral fraction was taken up in chloroform and was chromatographed on a silicic acid column (10 g). The major component was eluted as the second fraction (125 mg) with chloroform and was distilled from bulb to bulb. This oil showed single spot on a tlc plate (alumina) with chloroform or 2% methanol in chloroform as eluents. Oil **8** possesses their absorption at 1750, 1715, 1180, and 1070 cm^{-1}, the mass spectral peaks at m/e 296 (M^+, 12%), 281 (10), 251 (13), 237 (12), 223 (35), 198 (32) and 171 (100); λ_{max} 207.5 mμ (ε 3600); nmr signals at τ 8.98 (d, J = 6 Hz, 3 H), 8.70 (s, 3 H), 8.82 (s, 3 H), 8.67 (t, J = 7 Hz, 3 H), 8.06 (s, 3 H), and 5.80 (q, J = 7 Hz, 2 H). At the ionization voltage of 15 eV the intensity of the mass peaks at 296, 281, and 237 are enhanced.

From a tlc analysis the acidic fraction was shown to be a mixture of at least six components and was not investigated further.

Registry No.—Pulegone, 89-82-7; ethyl acetoacetate, 141-97-9; **3**, 18600-02-7; **4**, 19614-44-9; **5**, 19614-45-0; **6**, 19614-46-1; **8**, 19640-43-8; **10**, 18588-73-3; **11**, 19614-47-2.

Acknowledgment.—The authors are indebted to the National Research Council of Canada for financial support of this project and the purchase of an Hitachi-Perkin Elmer RMU-6E.

The Hydroxylamine Route to 3-Unsubstituted Isoxazolium Salts

D. J. WOODMAN AND Z. L. MURPHY[1]

Department of Chemistry, University of Washington, Seattle, Washington 98105

Received November 19, 1968

The importance of 3-unsubstituted isoxazolium salts in the synthesis of peptides[2] has spurred the improvement of preparative methods for the heterocyclic cations[3] and the development of routes to new types of the salts. Recently those with bulky groups on nitrogen have been made available by the SN1 alkylation of isoxazoles with alcohols and perchloric acid,[4,5] while the first N-aryl compounds **1** were obtained by a new pathway to the heterocyclic ring.[4] Our study of the latter route has now provided a one-step synthesis of 3-unsubstituted isoxazolium perchlorates directly from α-formyl derivatives of carbonyl compounds and N-substituted hydroxylamines.

(1) National Science Foundation Graduate Trainee, 1966–1969.
(2) R. B. Woodward and D. J. Woodman, *J. Amer. Chem. Soc.*, **90**, 1371 (1968).
(3) B. D. Wilson and D. M. Burness, *J. Org. Chem.*, **31**, 1565 (1966).
(4) R. B. Woodward and D. J. Woodman, *ibid.*, **31**, 2039 (1966).
(5) D. J. Woodman, *ibid.*, **33**, 2397 (1968).