Syntheses of ω-Phenyl-3-acetoxy-2,4-dioxoalkanes and Their Enol Contents

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(Received April 28, 1967)

Altenin, the substance phytopathologically toxic to the pear, has been reported to be ethyl 5-hydroxy-5-(1-hydroxyethyl)-4-oxotetrahydrofuroate,[1] and to possess the methyl reductone grouping as a partial structure.[2] It was pointed in a previous paper[3] that the enol form of altenin has some relation to its toxicity. Therefore, it is interesting to examine the enol content of reductones.

This paper will describe the syntheses and the enol contents of ω-phenyl-2, 4-dioxoalkanes (Ia—d), ω-phenyl-3-chloro-2, 4-dioxoalkanes (IIa—d), and ω-phenyl-3-acetoxy-2, 4-dioxoalkanes.[4]

The synthesis of Ib—d was carried out by the condensation of acetylacetone and halides (diphenyl iodonium chloride, benzyl chloride or phenylethyl bromide) in liquid ammonia.[5,6] The chlorination of I by sulfuryl chloride gave 3-chloro derivatives (II), which were then treated with potassium acetate to produce III. These 2, 4-dioxo compounds were purified by the formation of copper chelate compounds. It was, however, impossible

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3) N. Sugiyama, C. Kashima, M. Yamamoto, T. Takano and R. Mohri, *ibid.*, in press.
4) H. Böhme and H. Schneider, *Chem. Ber.*, **91**, 1100 (1958).
5) K. G. Hamptone, T. M. Harris and C. R. Hauser, *J. Org. Chem.*, **29**, 3511 (1964).
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to purify IIIb on account of the failure of the chelate compound to form.

The nuclear magnetic resonance peaks of the C-3 protons of I, II, and III are listed in the table. Compared with the peak intensity of phenyl protons, the peak intensity of a C-3 proton of the keto-form in these 2, 4-dioxo compounds indicates the keto-form percentage. The enol contents of I, II, and III thus calculated are also listed in the table. The decrease in the enol content from Ia to Id suggests that the electron-withdrawing effect of the phenyl group affects their enol content. Burdett[7] has reported that substitution in acetylacetone with an electron-withdrawing group such as chlorine at C-3 resulted in an increase in the enol form. However, the enol contents of II

$$CH_3\text{-}CO\text{-}\underset{\displaystyle X}{\underset{|}{CH}}\text{-}CO\text{-}(CH_2)_n\text{-}C_6H_5$$

Ia: X=H, n=0 IIa: X=Cl, n=0
Ib: X=H, n=1 IIb: X=Cl, n=1
Ic: X=H, n=2 IIc: X=Cl, n=2
Id: X=H, n=3 IId: X=Cl, n=3
IIIa: X=OAc, n=0
IIIb: X=OAc, n=1
IIIc: X=OAc, n=2
IIId: X=OAc, n=3

and III are smaller than that of I; IIa and III are especially much smaller. These facts suggest that the enol contents of these 2, 4-dioxo compounds are more affected by steric hindrance than by the electron-withdrawing effect of substituents at the C-3 and C-4 positions.

This method of synthesizing 3-acetoxy-2, 4-dioxo compounds is limited in the case of 3-acetoxy-2, 4-dioxoalkanes and 3-acetoxy-2, 4-dioxoarylalkanes. The present authors will report the synthesis of some 3-acetoxy-2, 4-dioxo compounds substituted by a hydroxyl or oxo group at the C-5 position in the near future.

Experimental

7-Phenyl-2, 4-dioxoheptane (Id). To 7.8 g (0.2 mol) of a sodium amide solution in 800 m*l* of liquid ammonia at −78°C, 10 g (0.1 mol) of acetylacetone were added. After stirring for one hour at −33°C, 18.5 g (0.1 mol) of phenylethyl bromide were added and the mixture was stirred continuously for three hours. To the reaction mixture 300 m*l* of anhydrous ether were added, and then the liquid ammonia was distilled off. After the addition of 100 g of ice, the mixture was acidified with hydrochloric acid and extracted several times with ether. The solvent was then removed, and the residue was distilled; bp 168—171°C/20 mmHg; yield, 43%. The yellow distillate was poured into an aqueous copper acetate solution to form copper chelate compounds (mp 160°C).

Found: C, 66.11; H, 6.45; Cu, 13.66%. Calcd for $C_{26}H_{30}O_4Cu$: C, 66.43; H, 6.43; Cu, 13.66%.

IR: 1570, 1520, 740, 700 cm^{-1}.

Chlorination of I. To 0.02 mol of a I solution in 20 m*l* of anhydrous benzene, there was added, drop

Table 1. The NMR peaks of C-2 proton and enol contents of ω-phenyl-2, 4-dioxoalkanes

Compound	Bp °C/mmHg	Mp of Cu chelate °C	NMR of C-3 proton*		Enol content* %
			τ (ppm)	intensity**	
Acetylacetone	—	230 (decomp.)[8]	6.52	0.10	90
Ia	135—142/18[9]	193 (decomp.)[9]	—	—	100
Ib	140—148/17[5]	220 (decomp.)[5]	6.35	0.05	95
Ic	157—159/18[6]	159[6]	6.63	0.15	85
Id	168—172/20	160	6.64	0.15	85
3-Chloro-acetylacetone	146—153/760	175 (decomp.)[10]	—	—	100
IIa	150—160/20[11]	210 (decomp.)	4.48	0.90	10
IIb	148—153/16	181 (decomp.)	5.33	0.25	75
IIc	167—171/21	187 (decomp.)	5.43	0.15	85
IId	181—182/18	140	5.47	0.30	70
3-Acetoxy acetylacetone	103—110/24[4]	240 (decomp.)	4.66	0.70	30
IIIa	—	220 (decomp.)	3.86	0.80	20
IIIc	—	183 (decomp.)	4.70	0.70	30
IIId	—	147	4.70	0.80	20

* Concentration: 15 vol%, Solvent: CCl_4, Temperature: 34°C.
** The peak intensity was estimated from that of phenyl protons.

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9) H. G. Walker, Jr., J. J. Sanderson and C. R. Hauser, *J. Am. Chem. Soc.*, **75**, 4105 (1953).
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by drop, 0.02 mol of sulfuryl chloride dissolved in 5 ml of anhydrous benzene. The mixture was stirred for several hours at room temperature and then washed with water. After the removal of the benzene, the residue was distilled. The distillate formed copper chelate compounds,

IIb. Bp 148—153°C/16 mmHg; yield, 83%.

Cu-chelate of IIb. mp 181°C (decomp.).

Found: C, 54.35; H, 4.15%. Calcd for $C_{22}H_{20}O_4Cl_2Cu$: C, 54.72; H, 4.18%.

IR: 1560, 720, 690 cm^{-1}.

IIc. Bp 167—171°C/21 mmHg; yield, 85%.

Cu-chelate of IIc. Mp 187°C (decomp.).

Found: C, 55.89; H, 4.93%. Calcd for $C_{24}H_{24}O_4Cl_2Cu$: C, 56.42; H, 4.72%.

IR: 1565, 760, 700 cm^{-1}.

IId. Bp 181—182°C/18 mmHg; yield, 72%.

Cu-chelate of IId. Mp 140°C.

Found: C, 57.71; H, 5.21%. Calcd for $C_{26}H_{28}O_4Cl_2Cu$: C, 57.94; H, 5.24%.

IR: 1560, 750, 700 cm^{-1}.

Acetoxylation of II. A mixture of 0.02 mol of II, 18 g of anhydrous potassium acetate, and 25 ml of glacial acetic acid was refluxed for several hours and then poured into an aqueous copper acetate solution to form copper chelate compounds, which recrystallized from a mixture of chloroform and petroleum ether.

Cu-chelate of IIIa. Mp 220°C (decomp.).

Found: C, 57.36; H, 4.34; Cu, 13.01%. Calcd for $C_{24}H_{22}O_8Cu$: C, 57.42; H, 4.42; Cu, 12.77%.

IR: 1750, 1580, 1560, 730, 700 cm^{-1}.

Cu-chelate of IIIc. Mp 183°C (decomp.).

Found: C, 59.96; H, 5.47; Cu, 10.95%. Calcd for $C_{28}H_{30}O_8Cu$: C, 60.26; H, 5.42; Cu, 11.39%.

IR: 1750, 1580, 750, 700 cm^{-1}.

Cu-chelate of IIId. Mp 147°C.

Found: C, 61.52; H, 5.86; Cu, 11.05%. Calcd for $C_{30}H_{34}O_8Cu$: C, 61.48; H, 5.85; Cu, 10.84%.

IR: 1750, 1580, 750, 700 cm^{-1}.

Nuclear Magnetic Resonance Spectra. An Hitachi H-60 high-resolution nuclear magnetic resonance spectrometer was used. Each sample was prepared from the corresponding copper chelate compounds by hydrolysis with sulfuric acid, and was then dissolved in carbon tetrachloride with a concentration of 15 vol%. The temperature was maintained at 34°C. TMS was used as the inner standard.