

## 28. *Some Disubstituted Derivatives of Imidazolidin-2-one.*

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1,3-Structures for bishydroxymethyl- and diacetyl-imidazolidin-2-one have been confirmed. This has permitted the assignment of infrared absorption frequencies in the 1600—1800  $\text{cm}^{-1}$  region for several imidazolidin-2-one and imidazolidine-2-thione derivatives.

THE structures of diacyl and bishydroxymethyl derivatives of imidazolidin-2-one have hitherto been assumed, by analogy with urea derivatives, to be (I;  $R = R' = \text{acyl}$  or hydroxymethyl;  $X = O$ ) rather than (II).

Treatment of imidazolidin-2-one with boiling acetic anhydride has yielded the diacetyl derivative, previously obtained only by an indirect method,<sup>1</sup> which might be the 1,2-diacetyl compound (II,  $R = R' = \text{Ac}$ ,  $X = O$ ) since its infrared spectrum shows a doublet at 1750 and 1760  $\text{cm}^{-1}$ .



Proof that bishydroxymethyl- and diacetyl-imidazolidin-2-one have structure (I) has been obtained from their nuclear magnetic resonance spectra. In the spectrum of the bishydroxymethyl derivative, protons in three types of environment were observed; the integrated peak areas gave the numbers of protons in each as 4.3 : 2.1 : 3.6, the corresponding chemical shifts ( $\delta$ ) were 2.56, 3.68, and 3.72, respectively. The structure (I;  $R = R' = -\text{CH}_2\cdot\text{OH}$ ,  $X = O$ ) has protons in three types of environment, four protons in ring  $\text{CH}_2$  groups, two in hydroxyl groups, and four in hydroxymethyl  $\text{CH}_2$  groups, whereas structure (II) contains five proton environments. The diacetyl compound has protons in

<sup>1</sup> Kirkwood and Wright, *J. Amer. Chem. Soc.*, 1954, **76**, 1836.

two types of environment, corresponding to chemical shifts ( $\delta$ ) of 2.52 and 3.83, the numbers of protons involved being 5.8 and 4.2, respectively, again consistent with structure (I; R = R' = Ac, X = O), but not (II) (three proton environments).

The ultraviolet spectrum of the diacetyl derivative of imidazolidine-2-thione supports the view that it also has the 1,3-structure (I; R = R' = Ac, X = S), since there is an absorption band at 252 m $\mu$  ( $\epsilon$  14,700), attributable to the C=S group ( $\lambda_{\max}$  230—260 m $\mu$ ,  $\epsilon$  ~20,000;<sup>2</sup> the absorption due to a single C=N as in acetoxime<sup>3</sup> is  $\lambda_{\max}$  190 m $\mu$ ,  $\epsilon$  5000). An attempt was made, therefore, to prepare 1,3-diacetyl-imidazolidin-2-one unambiguously from the thio-analogue<sup>4</sup> by reaction with hydrogen peroxide in the presence of dilute alkali, a method which gave almost quantitative yields of urea from thiourea.<sup>5</sup> An extra mol. of alkali was, however, consumed and the product was 1-acetyl-imidazolidin-2-one, which was also obtained from 1-acetyl-imidazolidine-2-thione<sup>4</sup> and 1,3-diacetyl-imidazolidin-2-one in the same conditions. Thus the monoacetyl compounds must have structure (I; R = Ac, R' = H, X = O or S).

Confirmation of the structures of the diacetyl compounds was obtained by sequential acylation.<sup>6</sup> Monoacetyl- and monopropionyl-imidazolidin-2-one were propionylated and acetylated, respectively. The products were identical.

Now that the structures of mono- and di-acetyl derivatives of imidazolidin-2-one and -2-thione have been established, it is possible to assign the bands in the 1600—1800 cm.<sup>-1</sup> region of the infrared spectra of these and related compounds with some certainty. 1,3-Diacetyl-imidazolidin-2-one gives two doublets, at 1700, 1710, and 1750, 1760 cm.<sup>-1</sup>. Comparison with the spectrum of the thio-analogue, which has one doublet at 1690, 1705 cm.<sup>-1</sup>, indicates that the higher-frequency doublet must be due to the ring-carbonyl group. The monoacetyl compounds exhibit a similar pattern of absorptions but with singlets instead of doublets. In view of the marked increase in the ring-carbonyl frequency on acetylation of imidazolidin-2-one it seems reasonable to assign the higher of the two carbonyl bands

Compound	$\nu$ (cm. <sup>-1</sup> )	
	Ring C=O	Acetyl C=O
Imidazolidin-2-one .....	1661 broad	—
Imidazolidine-2-thione .....	—	—
1-Acetyl-imidazolidin-2-one .....	1750	1650
1-Acetyl-imidazolidine-2-thione .....	—	1650
1,3-Diacetyl-imidazolidin-2-one .....	Doublet 1750, 1760	Doublet 1700, 1710
1,3-Diacetyl-imidazolidine-2-thione .....	—	Doublet 1690, 1705
1-Methyl-imidazolidin-2-one .....	1680	—
1-Acetyl-3-methyl-imidazolidin-2-one .....	1730	1670
1,1'-Ethylenedi-imidazolidin-2-one .....	Doublet 1680, 1690	—
1,1'-Ethylenedi-(3-acetyl-imidazolidin-2-one) .....	Doublet 1730, 1740	1690
1,3-Bishydroxymethyl-imidazolidin-2-one .....	1680	—
1-Hydroxymethyl-imidazolidin-2-one .....	1660	—

(1730 cm.<sup>-1</sup>) in the spectrum of 1-acetyl-3-methyl-imidazolidin-2-one and the doublet (1730, 1740 cm.<sup>-1</sup>) in the spectrum of 1,1'-ethylenedi-(3-acetyl-imidazolidin-2-one) to the ring-carbonyl vibration.

The imidazolidin-2-one ring-carbonyl frequency is relatively unchanged by hydroxymethylation. It occurs at 1660 and 1680 cm.<sup>-1</sup>, respectively, for 1-hydroxymethyl- and 1,3-bishydroxymethyl-imidazolidin-2-one.

#### EXPERIMENTAL

Infrared spectra were recorded on a Perkin-Elmer Infracord spectrophotometer. The samples were examined in potassium bromide pressed discs at a concentration of about 2 mg.

<sup>2</sup> Gillam and Stern, "An Introduction to Electronic Absorption Spectroscopy in Organic Chemistry," Arnold, London, 2nd edn., 1957, p. 70.

<sup>3</sup> Ref. 2, p. 49.

<sup>4</sup> Baer and Lockwood, *J. Amer. Chem. Soc.*, 1954, **76**, 1162.

<sup>5</sup> Kitamura, *J. Pharm. Soc. Japan*, 1934, **54**, 1.

<sup>6</sup> Stoughton, *J. Org. Chem.*, 1938, **2**, 514.

per 500 mg. of KBr. The ultraviolet spectrum of 1,3-diacetylimidazolidine-2-thione was determined on a  $2.7 \times 10^{-5}$ M-solution in methanol, by using a Unicam S.P. 700 recording spectrophotometer. Nuclear magnetic resonance spectra were recorded on the Varian 60MC spectrophotometer. 1,3-Diacetylimidazolidin-2-one was examined in deuteriochloroform with tetramethylsilane as the internal standard. 1,3-Bishydroxymethylimidazolidin-2-one was examined in D<sub>2</sub>O solution.

*1-Acyl Derivatives of Imidazolidin-2-one.*—Imidazolidin-2-one (1 g.) was treated with boiling acyl anhydride (10 ml.) for 30 min. Surplus anhydride was removed under reduced pressure (this was facilitated by addition of ethanol), and the solid residue was recrystallized. The following were prepared in high yield in this way: 1-acetyl-, m. p. 176—177° (from ethanol) (lit.,<sup>7</sup> 171.5—173°), and 1-propionyl-imidazolidin-2-one, m. p. 146—148° (from acetonitrile) (Found: C, 50.4; H, 6.95; N, 19.3. C<sub>8</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> requires C, 50.7; H, 7.1; N, 19.7%).

*1,3-Diacyl Derivatives of Imidazolidin-2-one and Related Compounds.*—The following were prepared in high yield by heating the parent compound (1 g.) with the appropriate acyl anhydride (5 ml.) at the b. p. for 4 hr. and working up as described for the mono-acyl derivative: 1,3-diacetylimidazolidin-2-one, m. p. 126—127° (from ethanol) (lit.,<sup>1</sup> 126.7—127.5°) (Found: C, 49.9; H, 6.2; N, 16.3. Calc. for C<sub>8</sub>H<sub>10</sub>N<sub>2</sub>O<sub>3</sub>: C, 49.4; H, 5.9; N, 16.5%); 1,3-dipropionyl-imidazolidin-2-one, m. p. 115—120° (from acetonitrile or ethyl acetate or after vacuum-sublimation) (Found: C, 54.25; H, 7.0; N, 14.95. C<sub>9</sub>H<sub>14</sub>N<sub>2</sub>O<sub>3</sub> requires C, 54.5; H, 7.1; N, 14.1%); 1-acetyl-3-propionylimidazolidin-2-one, from 1-acetylimidazolidin-2-one with propionic anhydride, m. p. 84—85° [from light petroleum (b. p. 40—60°)] (Found: C, 52.1; H, 6.7; N, 15.4. C<sub>8</sub>H<sub>12</sub>N<sub>2</sub>O<sub>3</sub> requires C, 52.2; H, 6.6; N, 15.2%), or from 1-propionylimidazolidin-2-one with acetic anhydride, m. p. and mixed m. p. 84—85° (Found: C, 52.3; H, 6.8; N, 15.2%); 1,1'-ethylenedi-(3-acetylimidazolidin-2-one) (from 1,1'-ethylenedi-imidazolidin-2-one<sup>8</sup> with acetic anhydride), m. p. 202—203° (from acetonitrile) (Found: C, 50.9; H, 6.4; N, 19.8. C<sub>12</sub>H<sub>18</sub>N<sub>4</sub>O<sub>4</sub> requires C, 51.0; H, 6.4; N, 19.8%); 1-acetyl-3-methylimidazolidin-2-one (from 1-methylimidazolidin-2-one<sup>9</sup> with acetic anhydride), m. p. 77.5—78.5° (from ethyl acetate) (Found: C, 50.8; H, 7.3; N, 19.8. C<sub>6</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> requires C, 50.7; H, 7.1; N, 19.7%).

*Oxidation of Acetylimidazolidine-2-thiones.*—Samples (100 mg.) of 1,3-diacetylimidazolidine-2-thione were suspended in water (5 ml.), hydrogen peroxide (90-vol.; 0.5 ml.) was added, and the mixture titrated with 0.1N-sodium hydroxide to a stable phenolphthalein end-point. One drop of hydrogen peroxide (90-vol.) was then added to ensure that an excess was present. 3.05 Moles of alkali were consumed per mole of 1,3-diacetylimidazolidine-2-thione. The reaction mixture was evaporated to dryness *in vacuo* and the residue was extracted with hot acetonitrile. The extract, on evaporation, yielded 1-acetylimidazolidin-2-one, (97%), m. p. 164—168° raised to 173—174° by recrystallization from acetonitrile and undepressed on admixture with an authentic specimen, m. p. 176—177°.

The reaction was repeated with 1,3-diacetylimidazolidin-2-one and 1-acetylimidazolidine-2-thione, 1.06 and 2.08 mol. of alkali being consumed. Almost theoretical yields of 1-acetylimidazolidin-2-one, identified by m. p. and mixed m. p., were obtained.

*1,3-Bishydroxymethylimidazolidin-2-one.*—This compound was prepared by Hoover and Vaala's method<sup>10</sup> and recrystallized from acetonitrile. It had m. p. 100—101° (lit.,<sup>10</sup> m. p. 99°).

*1-Hydroxymethylimidazolidin-2-one.*—A suspension of imidazolidin-2-one (5.3 g.) and para-formaldehyde (1.8 g.) in methanol (25 ml.) was made just alkaline by the addition of solid sodium hydroxide (~100 mg.) and warmed to 50°. The slightly cloudy solution was filtered hot and concentrated *in vacuo*, giving a syrup which crystallized as needles (6.6 g.). Repeated recrystallization of the product from 1,2-dichloroethane or ethyl acetate gave 1-hydroxymethylimidazolidin-2-one, m. p. 105—106° (Found: C, 41.5; H, 7.1; N, 24.3. C<sub>4</sub>H<sub>6</sub>N<sub>2</sub>O<sub>2</sub> requires C, 41.4; H, 6.9; N, 24.1%).

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<sup>7</sup> Hall and Schneider, *J. Amer. Chem. Soc.*, 1958, **80**, 6409.

<sup>8</sup> Wilson, U.S.P. 2,517,750/1950.

<sup>9</sup> Frick, Kottes, and Reid, *Textile Res. J.*, 1959, **29**, 314.

<sup>10</sup> Hoover and Vaala, U.S.P. 2,373,136/1945.