Tautomerism of 2-Amino-2-oxazolin-4-ones. II.

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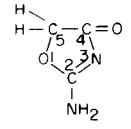
The study of the tautomerism of 2-amino-2-oxazolin-4-one (**1**) and its methyl derivatives has been completed. The methylation of **1** gave 2-imino-3-methyloxazolidin-4-one (**4**) and 2-methylamino-2-oxazolin-4-one (**7**). All attempts to isolate *O*-methyl derivatives failed. The uv, nmr, ir, and Raman spectra led to the definite conclusion, in agreement with the chemical evidence, that the 2-aminooxazolinic form **a**, if it is theoretically possible, predominates in all compounds investigated. Otherwise the 2-iminooxazolidinic form **b** predominates. The assignment of the carbonyl stretching is discussed on the basis of ir and Raman data. The nmr spectrum of compound **7** shows anomalous behaviour, most probably due to the existence of a monomer-dimer equilibrium.

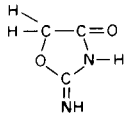
Tautomerism of 2-Amino-2-oxazolin-4-ones (II).

Following our brief communication (1), we now wish to give the full report of our research on the tautomerism of 2-amino-2-oxazolin-4-one (**1**), and its methyl derivatives, compounds **4** and **7**, and including further spectroscopic data. Compound **1** was initially formulated as 2-imino-4-keto-tetrahydrooxazole and the 2-iminic structure was for a long time assigned to the substances derived from this nucleus (2-6). Although the tautomerism of 5-aryl substituted members has recently been studied (5-11), no attention has been given up to now to the fundamental member **1**, and its five possible tautomeric structures.

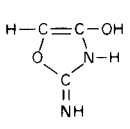
SCHEME 1



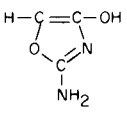
1a



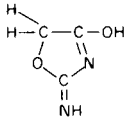
1b



1c



1d



1e

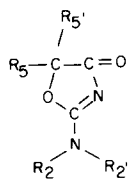
Of the methyl substituted derivatives, only 5,5′-dimethyl-2-amino-2-oxazolin-4-one (**3**) (8), 2-dimethylamino-2-oxazolin-4-one (**8**) (8) and 5-methyl-2-dimethylamino-2-oxazolin-4-one (**9**) (11) have been considered.

In the case of 2-methylimino-3-methyloxazolidin-4-one (**5**), structure **b** predominates and formula **c** can be excluded (1). A red shift of only 3 mμ is, in fact, noted when we pass from **5** to 5,5′-dimethyl-2-methylimino-3-methyl-oxazolidin-4-one (**6**) of unequivocal structure **b**; this weak bathochromic effect can be attributed to the two methyl groups in the 5-C position of compound **6**. Compound **4** shows almost the same value of λ max as **5**; the blue shift of 3 mμ with respect to **5**, in methanol, can be explained by the absence of the methyl group on the exocyclic nitrogen (as can be confirmed on the basis of the spectroscopic behavior of **7**). A comparison of the spectroscopic data of **5** and **6** led to the conclusion that, for **4** also structure **b** predominates. Compound **7** shows a blue shift of 5 mμ (methanol) with respect to **8** [dimethylated on the exocyclic nitrogen and having formula **a** (1)]; its value of the λ max is found at a higher wavelength than the compounds having a 2-iminic structure (**b**). The hypsochromic shift with respect to **8** is in perfect agreement with the introduction of only one methyl group on the exocyclic nitrogen; the introduction of methyl groups is, in fact, accompanied by a notable bathochromic effect, as has been ascertained for 5-aryl substituted members (8).

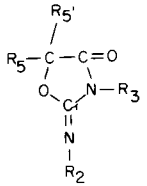
As reported (1), in the case of **1**, **2**, and **3** formula **b**

TABLE I

Uv Spectra (a)



a



b

N	Solvents: Cycloexane	Dioxane	Methylene-chloride	Acetonitrile	Methanol	Theoretical Tautomeric Equilibria	Predominating Forms
1		217.5 (4.29)		217 (4.33)	216 (4.35)	**a⇌b⇌c⇌d⇌e**	**a**
2		217.5 (4.35)		217 (4.32)	215.5 (4.36)	**a⇌b⇌c⇌d⇌e**	**a**
3		217 (b) (3.99)	217.5 (4.23)	217 (4.23)	215 (c) (4.35)	**a⇌b⇌e**	**a**
4		206 (4.06)		202.5 (4.10)	202 (4.14)	**b⇌c**	**b**
5	206 (4.08)				205 (4.14)	**b⇌c**	**b**
6	205 (4.11)				208 (4.13)		**b**
7		222 (4.36)	221.5 (4.33)	220 (4.36)	220 (4.36)	**a⇌b⇌c⇌d⇌e**	**a**
8		227 (4.40)	227 (4.41)	226 (4.43)	225 (d) (4.38)	**a⇌d**	**a**
9		226.5 (4.41)	227.5 (4.38)	227 (4.42)	225 (e) (4.39)	**a⇌d**	**a**
10		225 (4.49)	227 (4.38)	225 (4.39)	225 (4.37)		**a**

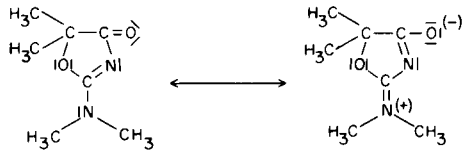
1: ($R_2 = R_2' = R_5 = R_5' = H$); **2**: ($R_2 = R_2' = R_5' = H$, $R_5 = CH_3$); **3**: ($R_2 = R_2' = H$, $R_5 = R_5' = CH_3$); **4**: ($R_2 = R_5 = R_5' = H$, $R_3 = CH_3$); **5**: ($R_2 = R_3 = CH_3$, $R_5 = R_5' = H$); **6**: ($R_2 = R_3 = R_5 = R_5' = CH_3$); **7**: ($R_2' = R_5 = R_5' = H$, $R_2 = CH_3$); **8**: ($R_2 = R_2' = CH_3$, $R_5 = R_5' = H$); **9**: ($R_2 = R_2' = R_5 = CH_3$, $R_5' = H$); **10**: ($R_2 = R_2' = R_5 = R_5' = CH_3$).

(a) $\lambda_{max}^{m\mu}$ (Log ϵ) values; 2-3 $.10^{-3}$ *M* solutions; 0.1-0.2 cm thickness cells; N_2 flushing. (b) Shoulder at 207 mμ. (c) 217 mμ (ϵ, 23400) (11). (d) 227 mμ (Log ϵ 4.31) (17). (e) 227 mμ (ϵ, 27300) (11).

can be excluded; the passage from **1**, and therefore also from 5-methyl-2-amino-2-oxazolin-4-one (**2**) and **3**, to **7** and dimethylated **8** (on the exocyclic nitrogen) is accompanied by a red shift from 216, to 220 for **7** and 225 mμ for **8**, in methanol. This bathochromic shift is in perfect agreement with a gradual substitution of amine protons with methyl groups. We can, therefore, conclude that **7** is methylated on the exocyclic nitrogen, and since its spectroscopic characteristics agree with those of **1**, **2** and **3**, we can also exclude the presence of the tautomeric forms **b**, **c**, and **d** for compound **7**; derivative **7** was therefore assigned the structure of 2-methylamino-2-oxazolin-4-one. However, form **e** cannot be excluded with such certainty. The conjugate chromophore system for this form is in fact analogous to that of form **a**, and none of the compounds examined furnished positive data in this respect. However, chemical data relative to **4** and **7** deem form **e** improbable. Compounds **4** and **7** were obtained by methylation of **1** with diazomethane. Varying the methylation conditions gave different yields and it was also possible to isolate a small quantity of 2-dimethylamino-2-oxazolin-4-one (**8**), but no *O*-methyl derivatives were obtained [not even by methylation with methyl iodide in dimethylformamide or with dimethylsulphate and methyl iodide in the presence of silver oxide (12)]. The enolic structures **1c**, **1d**, and **1e** are, therefore, not very probable and this agrees with our finding that *O*-methylated compounds for the aryl substituted series have never been isolated (10).

A comparison of the proton resonances of **5** and **6** led us to exclude structure **c** for **5**, which was, other than **b**, the only structure admitted for this substance (1). No signal can be observed, other than those reported in Table II, in the nmr spectrum of compound **4**, which agrees with its formulation as 3-methyl-2-imino-oxazolin-4-one; for this compound as for **5** the enolic form **c** can, as a consequence, be excluded. Tetramethylated compound **10**, having structure **a**, shows two signals each corresponding to three protons, for the two methyl groups on the exocyclic nitrogen. We attributed the two peaks to the partial double bond character of the 2-C bond and the dimethylamino group.

SCHEME 2



10, I 10, II

These two signals cannot be due to coupling since the structure does not seem to permit it. This explanation is also supported by nmr data of 5-methyl-2-dimethylamino-2-oxazolin-4-one (**9**) and of compound **8**. These results are in agreement with those of 2-dimethylamino-

TABLE II

Nmr Spectra (a)

N	Solvents	HN-2(C)	H_3CN-2(C)	H_3C-3(N)	H-5(C)	H_3C-5(C)
1	$(CD_3)_2SO$	1.65 (s), 2H			5.48 (s), 2H	
2(b)	$(CD_3)_2SO$	1.65 (s), 2H			5.28 (q), 1H	8.67 (d), 3H
3	$(CD_3)_2SO$	1.69 (s), 2H				8.65 (s), 6H
4	$CDCl_3$	4.03 (s), 1H		6.89 (s), 3H	5.40 (s), 2H	
5	$CDCl_3$		6.99 (s), 3H	6.95 (s), 3H	5.39 (s), 3H	
6	$CDCl_3$		7.01 (s), 3H	6.98 (s), 3H		8.50 (s), 6H
7	$(CD_3)_2SO$	1.41 (s) 1H 0.20 (s)	7.12 (s) 3H 7.20 (s)		5.43 (s) 2H 5.46 (s)	
8(c)	$CDCl_3$		6.86 (s), 3H 6.75 (s), 3H		5.37 (s), 2H	
9	$CDCl_3$		6.88 (s), 3H 6.77 (s), 3H		5.21 (q),1H	8.47 (d), 3H
10	$CDCl_3$		6.92 (s), 3H 6.78 (s), 3H			8.50 (s), 6H

(a) Chemical shifts in τ units ($\Delta \pm 0.01\ \tau$); TMS internal standard; s = singlet, d = doublet, q = quartet. (b) q: 5.12; 5.24; 5.35; 5.47 τ (1:3:3:1). d: 8.61; 8.73 τ (1:1). (c) 6.85; 6.75; 5.36 τ (3).

5-phenyl-2-oxazolin-4-one (11). Compounds **5** and **6** can in theory exist as *cis* or *trans* isomers, according to the methyl position on the exocyclic iminic nitrogen; on the basis of their nmr spectra they seem to have, however, only one of the two possible geometrical isomers, or else, the chemical shifts for these forms cannot be distinguished from one another. This is in accord with data on 5-phenyl-3-methyl-2-methyliminooxazolidin-4-one (11).

For compounds **1**, **2**, and **3**, as already mentioned (1), the only structure compatible with the nmr spectroscopic results is structure **a**. We need only note that from a comparison of the spectra of compounds **1**, **2**, **3**, **7**, and **4** the amino protons in the 2-C position are found to have lower field values than imino protons in the same position. This fact agrees with observations made on 5-aryl substituted members (10), and might be explained by the contribution of resonance form **II**, which in the case of the 2-aminic structures decreases the electron density around these protons.

The nmr spectrum of **7** is, however, not easily interpretable (Figure 1). In fact all expected resonances are found to be doubled. The signal intensity ratios due to the methylamino group in 2-C, and those due to the H-5(C) protons, are about 1:2. The signals at τ 1.41(s) and τ 0.2(s) are too weak for a useful quantitative interpretation. However, these results agree with the equally anomalous result obtained for 5-phenyl-2-methylamino-2-oxazolin-4-one (11) (chloroform), due to a monomer-dimer equilibrium. As we have seen, the uv spectra of **7**, obtained in four different solvents, show almost identical λ max and log ϵ values: the existence of an important tautomeric equilibrium can most probably be excluded. Due to the low solubility of **7**, even in dimethylsulfoxide, it was not possibility to make a thorough investigation of its nmr spectroscopic behavior at varying concentrations. The spectra of the saturated and half-saturated solutions do not show sufficient chemical shifts in position and intensity of the methyl group signals (the only group that is still distinctly identifiable in a more dilute solution) to allow a precise assignment.

The ir spectra of this class of compounds have been reported and discussed only in the solid phase (5,6,9,10); exceptions are the spectrum of 5-phenyl-2-amino-2-oxazolin-4-one (13) in dioxane and the spectrum of 5-phenyl-2-methylamino-2-oxazolin-4-one (11) in chloroform.

3500-3000 cm^{-1} zone.

As already mentioned (1), **b** $\rightleftharpoons$ **c** tautomerism can be excluded for compound **5** on the basis of the transparency of the 3500-3000 cm^{-1} region. Compound **4** gives a band at 3340 cm^{-1} (carbon tetrachloride) (that appears at 3270 cm^{-1} in the solid state because of hydrogen bonding) which is to be attributed to the NH stretching of the 2-imino group. This confirms structure **b** for compound **4**, (at least in solution). In the solid state, compounds **10**, **9**, and **8** give complex patterns in the 3000-2800 cm^{-1} zone. These decrease even more in intensity and even disappear when done in solution. In both cases, these bands are due to CH stretching of the C-CH_3 groups. None of these compounds gives, either in solution or in the solid state, bands higher than 3000 cm^{-1} and the enolic tautomeric forms can again be excluded.

Compounds **1**, **2**, and **3** are also transparent beyond 3250 cm^{-1}. However, in the solid state, they absorb diffusely between 3300 and 2700 cm^{-1}. These bands can be attributed to the hydrogen-bonded amino group [accordingly to Suterland (20) it can be assumed that in

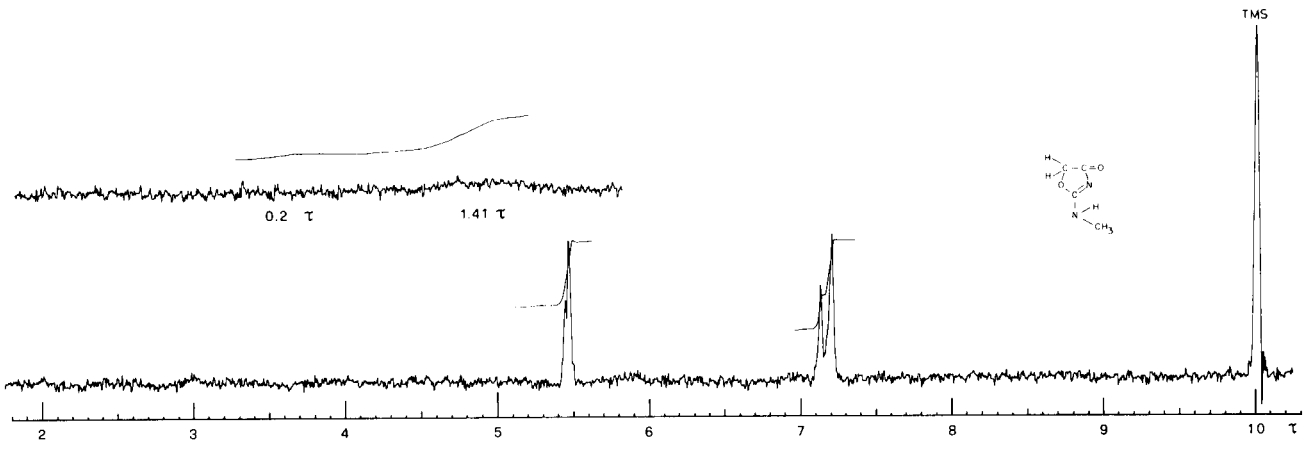


Figure 1. Nmr spectrum (DDMS) of 2-Methylamino-2-oxazolin-4-one (**7**).

TABLE III

Infrared (a) and Raman Data

		Approximate Description						
		Ir				Raman		
N	Solvents	$-NH_2$ Stretch	> NH Stretch	> C=O Stretch	> C=N Stretch	> C=O Stretch	> C=N Stretch	Predominating Forms
1	CH_3CN	3340 w 3260 w		1744 vw	1648 vs	1747 s (b) 1733 vs	1650 w	a
2	CH_3CN	3340 w 3260 w		1744 vw	1642 vs	1744 vs (c)	(not detectable)	a
3	CH_3CN	3340 w 3260 w		1742 w	1641 vs	1735 vs (b)	(not detectable)	a
4	CCl_4		3340 w	1771 m	1706 vs	1760 vs (b)	(not detectable)	b
5	CS_2			1768 vw	1715 vs	1770 vs (b) 1754 vs	1712 vw	b
6	CS_2			1767 w	1711 vs			b
7	CH_2Cl_2		3430 w	1740 w	1658 m 1622 vs			a
8	CCl_4			1740 w	1628 vs	1735 vs (b)	1620 vw	a
9	CCl_4			1742 m	1618 vs	1741 vs (d)	1620 vw	a
10	CCl_4			1743 m	1618 vs	1743 vs (d)	1615 w	a

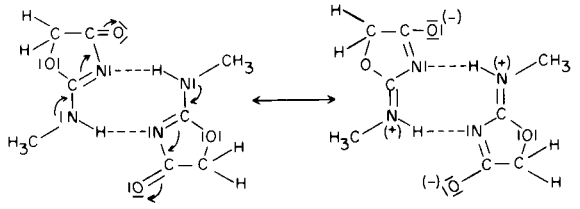
(a) 0.1, 0.2, 0.5 and 1 mm thickness cells; $\tilde{\nu}$ = cm^{-1}; vw = very weak, w = weak, m = medium, s = strong, vs = very strong. (b) Solid state. (c) Ethanol. (d) Liquid.

these compounds the imino group is actually bridged with other nitrogen atoms] and are resolved, in methylcyanide solution, into two bands at 3340 and 3260 cm^{-1}, assigned to the asymmetric and symmetric stretching vibrations of the amino group. The low frequency can be explained by the persistance, even in solution, of hydrogen bonds. The amino deformation can be found at about 1560 cm^{-1} (methyl cyanide).

The solid state spectrum of compound **7** is even more complex but in dilute methylene chloride solution these bands disappear and only one band at 3430 cm^{-1} is observed. This must be assigned to the free imino stretching and favors structure **a**.

Much of the physical data collected for the amino compounds (**1**, **2**, **3**, and **7**) agree with strongly polar structures having pronounced hydrogen bonds in the solid state: *i.e.*, very high melting points over 200° (this is also true for all analogous compounds previously reported). Furthermore, compounds **1**, **2**, **3**, and **7** are all fairly soluble in water, moderately soluble in alcohol, but only slightly soluble in the common organic solvents. The intermolecular hydrogen bond of compound **7** can be formulated as shown below, by analogy with the 5-phenyl homologue (11); its singular behavior should probably be attributed to the electron density contribution on the exocyclic nitrogen atom by the methyl group, which could stabilize the dimer form.

SCHEME 3



1800-1500 cm^{-1} zone.

In 2-imine type compounds, **6** (of formula **b**), **4** and **5**, show an initial band around 1770-1760 cm^{-1}, of very low intensity, especially in solution. A second, very intense zone of absorption is found between 1715-1700 cm^{-1}; likewise, in 2-amine type derivatives, **10** (of formula **a**), **8** and **9** show a band of low intensity between 1735-1710 cm^{-1} and a second one, very strong, at 1680-1600 cm^{-1} (potassium bromide). In both cases the strong absorption at the lower frequency can be assigned to the stretching of exo and endocyclic -C=N, respectively, as in the case of 5-phenyl substituted oxazolidones (10). However, the higher frequency bands cannot be directly attributed to the carbonyl stretching of the 5-membered rings because of their weak intensity in both the solid state and in solution, and a more detailed discussion is required.

An effective keto-enol tautomerism is not possible for compounds **6** and **10**, and can be excluded for **5**, **8**, and **9** also on the basis of the transparency of the 3500-3000 cm^{-1} zone; tautomerism therefore cannot cause the low intensity of carbonyl stretching. Even compounds **1**, **2**, and **3**, which permit tautomerism between the imine and 2-amine forms show maxima, in dilute solution (methyl cyanide; chloroform) similar to those of **10**, **9**, and **8**.

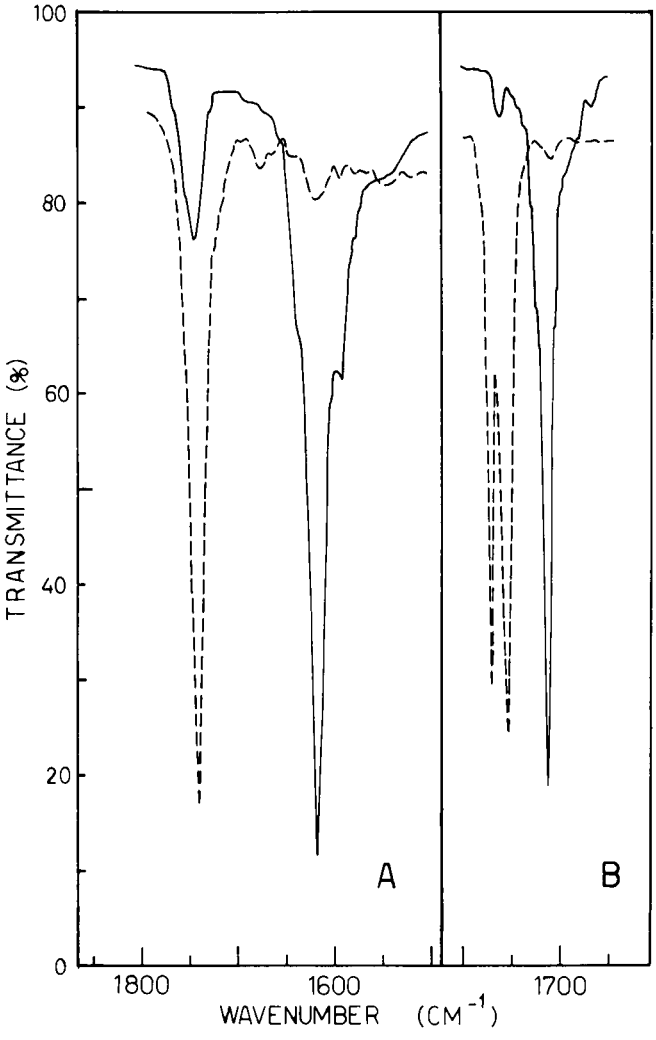


Figure 2. A - Spectra of 5,5'-Dimethyl-2-dimethylamino-2-oxazolin-4-one (**10**): ——— ir (carbon tetrachloride); - - - - - - - Raman (liquid).

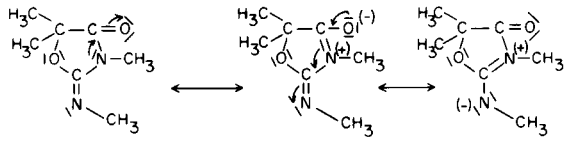
B - Spectra of 2-Methylimino-3-methyl-oxazolidin-4-one (**5**): ——— ir (carbon disulfide); - - - - - - - Raman (solid).

These results are in agreement with what is expected for conjugated 2-amine derivatives of **a** structure (1), at least in these solvents, but in this case also the weak intensity of the 1740 cm^{-1} band must be noted. On the other hand, the frequency of this absorption is in agreement with what is to be expected for amido five-membered rings (14-20). Exceptions, however, can be noted: in isoxazolin-3-ones (21) and in 5-amino-isoxazolin-3-ones (22,23), the $\bar{\nu}$ C=O is assigned to bands between 1657 and 1667 cm^{-1}, the lowering of the frequency being attributed to the contribution of the resonance form having separated charges on the endocyclic nitrogen and on the oxygen of the carbonyl group. However, in our case it was impossible to attribute the higher frequency bands to combination tones.

To obtain further information several Raman spectra (Table III) of these compounds, were carried out in the solid state and in solution (when their solubility characteristics permitted it) (Figure 2).

In the 1700-1620 cm^{-1} range the bands of strong intensity in the ir spectra became very weak, whereas in the 1770-1730 cm^{-1} range the absorptions were very strong; this allowed us to confirm the attribution of the 1770-1730 cm^{-1} bands to fundamental vibrations; nevertheless, we believe it is incorrect, especially for these compounds to speak of single C=O and C=N group vibrations; a more acceptable explanation can be given considering the vibration of the whole conjugated system, the most important limiting forms being **I**, **II** for the aminic structure and **III**, **IV**, **V** for the iminic one (24):

SCHEME 4



6, III 6, IV 6, V

The ir spectra of **8**, **9**, and **10** show an additional band of variable intensity at 1613, 1588 and 1590 cm^{-1}, respectively, in carbon tetrachloride solution. Although it can be reasonably assigned to combination tones of fundamentals in the fingerprint zone, easily detectable in solid phase, the hypothesis of a rotational isomerism due the conjugated dimethylamino group, cannot be discarded *a priori*. Compound **7** shows two bands in a saturated solution of chloroform, at about 1658 and 1622 cm^{-1}, of strong intensity; by varying the concentration in the ratio of 1:0.8:0.5 the relative intensities are greatly changed (the 1622 cm^{-1} increasing its intensity). This is accordance with the existence of a dimer-monomer equilibrium; unfortunately, due to the low solubility of **7**, the NH stretching zone cannot be extensively studied.

Some of the Raman spectra in solid phase show a clear splitting of the 1770-1730 cm^{-1} zone bands (Figure 2), corresponding to shoulders in the complex pattern of the ir spectra (potassium bromide pellet); they must be attributed to combination tones or to crystal effects; these compounds have been checked by tlc (also glc for **5**) and the existence of isomeric reaction products can be excluded.

EXPERIMENTAL

The uv spectra were recorded on a Cary Model 14 spectrophotometer. The nmr spectra were registered on a Varian A 56-60, 60 MC instrument. The chemical shifts are given relative to tetramethylsilane as an internal standard. The ir spectra were measured on a model 447 Perkin-Elmer apparatus and the Raman spectra on a model 81 Cary apparatus, equipped with an Argon-ion Laser, emitting at 4880 Å, using 0.5 or 5 cm cells for the liquids. Analysis by thin layer chromatography was carried out on Kieselgel F_{254} 0.25 mm thin plates, 1-butanol-water saturated as solvent. An H-P 5750 apparatus was used for the glc test of **5** (column temperature 120°).

Compounds **1**, **2**, **3**, **8**, and **9** were prepared essentially as described in the literature. The related reference, the analytical data, and some differences in the purification procedures used are reported. The synthesis of compounds **5** and **6** from *N,N'*-dimethylcarbodiimide and α-hydroxy esters is reported in our preceding investigation (26). Melting points are uncorrected.

2-Amino-2-oxazolin-4-one (**1**).

Compound **1** had m.p. 246-247° from ethanol [lit. (2) 246-247°].

Anal. Calcd. for $C_3H_4N_2O_2$: C, 36.01; H, 4.03; N, 27.99. Found: C, 36.2; H, 4.07; N, 28.02.

5-Methyl-2-amino-2-oxazolin-4-one (**2**).

Compound **2** had m.p. 225-226° from water [lit. (2) 226°].

Anal. Calcd. for $C_4H_6N_2O_2$: C, 42.11; H, 5.30; N, 24.55. Found: C, 42.04; H, 5.33; N, 24.68.

5,5'-Dimethyl-2-amino-2-oxazolin-4-one (**3**).

Compound **3** had m.p. 248-250° from ethanol [lit. (8) 245-247°; lit. (25) 243-244°].

Anal. Calcd. for $C_5H_8N_2O_2$: C, 46.86; H, 6.29; N, 21.86. Found: C, 47.03; H, 6.36; N, 21.62.

2-Imino-3-methyl-oxazolidin-4-one (**4**).

It was possible to isolate compound **4** together with compound **7**, from the products of **1** methylated with diazomethane. Compound **4** was isolated from the benzene extract in the course of the reaction (see for **7**).

If petroleum ether (b.p. 40-70°) was added to this benzene extract until the solution came turbid, a precipitate was obtained, which was found to be **7**. The filtered benzene-petroleum ether mixture was completely evaporated to give a residue, **4**, which was purified by repeated vacuum sublimation (0.01 mm Hg at 40-50°), m.p. 89-91°.

Anal. Calcd. for $C_4H_6N_2O_2$: C, 42.11; H, 5.30; N, 24.55. Found: C, 41.83; H, 5.29; N, 24.39.

2-Methylamino-2-oxazolin-4-one (**7**).

To a suspension in absolute ether of 0.580 g. (6 mmoles) of **1** was added an excess of diazomethane in ether (0.504 g., 12 mmoles). To this mixture 30 ml. of methanol was then added in several portions, shaking occasionally (27). The reaction was stopped when almost all of the solid had dissolved. The mixture was filtered and the solvent removed under reduced pressure. The residue was extracted with hot benzene; the benzene-insoluble fraction was dissolved in ethanol; ether was added and crude compound **7** precipitated, which was purified by recrystallization from ethanol. The substance was obtained in a highly pure state by sublimation (0.01 mm Hg at 100-110°), m.p. 198-200°.

Anal. Calcd. for $C_4H_6N_2O_2$: C, 42.11; H, 5.30; N, 24.55. Found: C, 41.83; H, 5.32; N, 24.21.

2-Dimethylamino-2-oxazolin-4-one (**8**).

This product, prepared according to the literature (8), was also isolated in small quantities from the methylation of **1** with a strong excess of diazomethane. It was recrystallized from the benzene solution by the addition of petroleum ether 40-70°; m.p. 108-109° from carbon tetrachloride [lit. (17) 108.5-109°].

Anal. Calcd. for $C_5H_8N_2O_2$: C, 46.86; H, 6.29; N, 21.86. Found: C, 46.69; H, 6.18; N, 22.03.

5-Methyl-2-dimethylamino-2-oxazolin-4-one (**9**).

The method used for the 5-aryl homologue (11) was modified as follows: a benzene solution of acetic acid was added dropwise to the previously reacted mixture (α-ethyl lactate, dimethyl cyanamide and sodium hydride in benzene), causing sodium acetate to precipitate. The mixture (*p*H = 6) was then distilled under reduced pressure (14 mm Hg) and a quantity of dimethyl urea was collected. A further distillation (0.1 mm Hg, 119-122°) gave crude compound **9**, m.p. 39-40° (sublimed at 50° and 0.01 mm Hg), [lit. (11) 39-40°].

Anal. Calcd. for $C_6H_{10}N_2O_2$: C, 50.69; H, 7.09; N, 19.7. Found: C, 50.34; H, 7.36; N, 19.60.

5,5'-Dimethyl-2-dimethylamino-2-oxazolin-4-one (**10**).

This compound was prepared by cyclizing dimethyl cyanamide and anhydrous methyl α-hydroxyisobutyrate (by azeotropic distillation with benzene) in the presence of sodium hydride and collecting the fraction boiling at 136-138°. The sodium hydride used was a 20% dispersion. The dimethyl cyanamide was prepared as described (28) from cyanamide and dimethyl sulphate in an alkaline solution. The addition of 30% sodium hydroxide must be done dropwise, while keeping the mixture at 35-39° and carefully controlling the temperature because if large portions are added the reaction easily goes out of control. To a suspension of 1 g. (8.34 mmoles) of 20% sodium hydride in 15 ml. of anhydrous benzene was added 5.9 g. (50 mmoles) of anhydrous methyl α-hydroxyisobutyrate. The mixture was refluxed for 1 hour, cooled to room temperature and 3.5 g. (50 mmoles) of dimethyl cyanamide (b.p. 52° at 14 mm Hg) was added. The mixture was then refluxed for 5 hours. After cooling, the reaction mixture was extracted with 25 ml. of distilled water and the aqueous phase was removed. The oil obtained was dissolved in methanol, dried with sodium sulphate and filtered. The addition of acetone caused a solid of m.p. 215-217° to precipitate. This solid was not studied further. The oily product obtained by removal of the solvent, solidified in an ice-salt mixture and sublimed, cooling the refrigerating apparatus to 2-4°. A white solid was collected at 50-60° and 0.05 mm Hg, which, by resublimation, gave a product of m.p. 14-16°.

Anal. Calcd. for $C_7H_{12}N_2O_2$: C, 53.83; H, 7.74; N, 17.94. Found: C, 53.38; H, 7.79; N, 17.67.

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REFERENCES

(1) G. Rapi, M. Ginanneschi, E. Belgodere, *Chimica e Industria*, 52, 1126 (1970).

(2) W. Traube and R. Asher, *Ber.*, 46, 2077 (1913).

(3) J. W. Clark-Lewis, *Chem. Rev.*, 58, 63 (1958).

(4) H. Aspelund, *Acta Acad. Aboensis Math. et Phis.*, 12, 1 (1939).

(5) H. Najer, R. Giudicelli, E. Joannie, Voisinet and M. Joannic, *Bull. Soc. Chim. France*, 1226 (1961).

(6) H. Najer and R. Giudicelli, *ibid.*, 1231 (1961).

(7) C. F. Howell, N. Q. Quinones and R. A. Hardy, *J. Org. Chem.*, 27, 1686 (1962).

(8) C. F. Howell, N. Q. Quinones and R. A. Hardy, *ibid.*, 27, 1679 (1962).

(9) H. Najer, R. Giudicelli, J. Menin and J. Loiseau, *Bull. Soc. Chim. France*, 47 (1964).

(10) H. Najer, R. Giudicelli, J. Menin and N. Voronine, *ibid.*, 207 (1967).

(11) C. F. Howell, W. Fulmor, N. Q. Quinones and R. A. Hardy, *J. Org. Chem.*, 29, 370 (1964).

(12) K. Eichenberger, E. Ganz, J. Bruey, *Helv. Chim. Acta*, 38 (1955).

(13) H. Najer, R. Giudicelli, J. Menin, and J. Loiseau, *Compt. Rend.*, 254, 2591 (1962).

(14) M. Pianka and D. J. Polton, *J. Chem. Soc.*, 938 (1960).

(15) A. M. Comrie, D. Dingwall, and J. B. Stenlake, *ibid.*, 5713 (1963).

(16) J. F. Giudicelli, J. Menin, and H. Najer, *Bull. Soc. Chim. France*, 1099 (1968).

(17) J. F. Giudicelli, J. Menin, and H. Najer, *ibid.*, 874 (1969).

(18) J. W. Clark-Lewis, *Chem. Rev.*, 58, 63 (1958).

(19) R. N. Jones and C. Sandorf, "The Application of Infrared and Raman Spectrometry to the Elucidation of Molecular Structure" Interscience, New York, N. Y., (1956).

(20) L. J. Bellamy, "The Infrared Spectra of Complex Molecules," J. Wiley and Sons, Inc., New York, 1960, pp. 213-215 and 252-255.

(21) A. J. Boulton, A. R. Katritsky, A. Majid Hamid and S. Oksne, *Tetrahedron*, 20, 2835 (1964).

(22) C. L. Bell, C. N. V. Nambury, and L. Bauer, *J. Org. Chem.*, 26, 4923 (1961).

(23) L. Bauer, C. N. V. Nambury, and C. L. Bell, *Tetrahedron*, 20, 165 (1964).

(24) B. Lunelli, C. Pecile, *Gazz. Chim. Ital.*, 96, 612 (1966).

(25) H. Aspelund, *Acta Acad. Aboensis Math e Phys.*, 26, 8 (1967); *Chem. Abstr.*, 68, 39523b (1968).

(26) G. Rapi, G. Sbrana, G. Gelsomini, *J. Chem. Soc., C*, 3827 (1971).

(27) R. Gompper in "Advances in Heterocyclic Chemistry," 2, 245. A. R. Katritzky, Ed., Academic Press, New York, N. Y., (1963).

(28) O. Diels, R. Gollman, *Ber.*, 44, 3165 (1911).