Russian Journal of Organic Chemistry, Vol. 39, No. 10, 2003, pp. 1477–1483. Translated from Zhurnal Organicheskoi Khimii, Vol. 39, No. 10, 2003, pp. 1546–1552.

Dedicated to Full Member of the Russian Academy of Sciences B.A. Trofimov on the 65th Anniversary of His Birth

Synthesis of 2-(1-Alkoxyvinyl)oxazolidines by Condensation of 2-Alkoxypropenals with 2-Aminoalkanols and Ring–Chain Tautomerism of the Products

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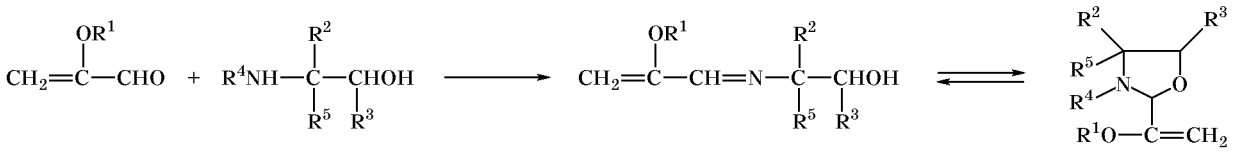
Received June 27, 2003

Abstract—Reactions of 2-alkoxypropenals with 2-aminoalkanols afforded tautomeric mixtures of previously unknown 2-(1-alkoxyvinyl)oxazolidines and imino alcohols. The condensation takes 2 h at room temperature (89–100%) or 1–5 min under microwave irradiation. The tautomeric equilibrium shifts toward the open-chain structure with increase in the solvent polarity ($CDCl_3$, CD_2OD, DMSO-d_6, D_2O) and temperature. The presence of substituents in the oxazolidine ring raises the stability of the cyclic tautomer.

2-Vinyl- and especially 2-vinyl-*N*-alkyloxazolidines are widely used in organic synthesis [1], specifically for the preparation of functionalized *cis*-3,4-disubstituted β-lactams [2], α-amino-β-hydroxy acids [3], and cyclopropylcarbaldehydes [4]. These compounds are readily involved in such processes as ene reaction [5], dihydroxylation [6], and epoxidation [5, 7–9]. The resulting epoxyoxazolidines turned out to be valuable synthons in the preparation of pheromones and intermediate product in the synthesis of taxol [8, 9]. 2-Alkenyloxazolidines are usually prepared by condensation of β-aminoalkanols with α,β-unsaturated aldehydes [4, 8, 10] or the corresponding acetals [6, 11]. However, no examples have so far been reported on reactions of α-alkoxyacroleins with β-amino alcohols. Such reactions could give rise to 2-(1-alkoxyvinyl)oxazolidines. Unlike the vinyl group in 2-ethenyloxazolidines, alkoxyvinyl group can be subjected to hydrolysis with a view to obtain 2-acetyloxazolidines which attract interest as intermediate products in the synthesis of O-substituted α-hydroxy aldehydes [12].

The goal of our present study was to find optimal conditions for the reaction of 2-alkoxypropenals with various 2-aminoalkanols and examine the state of tautomeric equilibrium between the cyclic oxazolidine and open-chain imino forms of the products with regard to the solvent polarity and substituent nature

Scheme 1.



Ia, Ib **IIa–IIe** **IIIa–IIIf** **IVa–IVj**

I, R^1 = Et (**a**), Me (**b**); **II**, $R^2 = R^3 = R^4 = R^5$ = H (**a**); R^2 = Et, $R^3 = R^4 = R^5$ = H (**b**); $R^2 = R^5$ = Me, $R^3 = R^4$ = H (**c**); $R^2 = R^3 = R^5$ = H, R^4 = Me (**d**); $R^2 = R^5$ = H, $R^3 = R^4$ = Me (**e**); **III**, **IV**, R^1 = Et, $R^2 = R^3 = R^4 = R^5$ = H (**a**); R^1 = Me, $R^2 = R^3 = R^4 = R^5$ = H (**b**); $R^1 = R^2$ = Et, $R^3 = R^4 = R^5$ = H (**c**); R^1 = Me, R^2 = Et, $R^3 = R^4 = R^5$ = H (**d**); R^1 = Et, $R^2 = R^5$ = Me, $R^3 = R^4$ = H (**e**); R^1 = Me, $R^2 = R^5$ = Me, $R^3 = R^4$ = H (**f**); R^1 = Et, $R^2 = R^3 = R^5$ = H, R^4 = Me (**g**); R^1 = Me; R^1 = Me, $R^2 = R^3 = R^5$ = H, R^4 = Me (**h**); R^1 = Et, $R^2 = R^5$ = H, $R^3 = R^4$ = Me (**i**); R^1 = Me, $R^2 = R^5$ = H, $R^3 = R^4$ = Me (**j**).

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Reactions of 2-alkoxypropenals **Ia** and **Ib** with 2-aminoalkanols **IIa**–**IIf**[a]

Run no.	R^1 (**I**)	R^2, R^3, R^4, R^5 (**II**)	Solvent (ε)		Product ratio, mol %	
			reaction	NMR	**III**	**IV**
1	Et	$R^2 = R^3 = R^4 = R^5 = H$	$CDCl_3$ (4.81)[b]	$CDCl_3$	83	16
2	Et	$R^2 = R^3 = R^4 = R^5 = H$	CD_3OD (32.7)	CD_3OD	96.2	–
3	Et	$R^2 = R^3 = R^4 = R^5 = H$	DMSO-d_6 (46.45)	DMSO-d_6	100	–
4	Et	$R^2 = R^3 = R^4 = R^5 = H$	D_2O (78.3)	D_2O	100	–
5	Me	$R^2 = R^3 = R^4 = R^5 = H$	$CDCl_3$ (4.81)[c]	$CDCl_3$	92.3	7.4
6	Me	$R^2 = R^3 = R^4 = R^5 = H$	$CDCl_3$ (4.81)[b]	$CDCl_3$	75	25
7	Me	$R^2 = R^3 = R^4 = R^5 = H$	CD_3OD (32.7)	CD_3OD	100	–
8	Me	$R^2 = R^3 = R^4 = R^5 = H$	DMSO-d_6 (46.45)	DMSO-d_6	100	–
9	Me	$R^2 = R^3 = R^4 = R^5 = H$	D_2O (78.3)	D_2O	100	–
10	Et	R^2 = Et, $R^3 = R^4 = R^5 = H$	$CHCl_3$	$CDCl_3$	49	15/35[d]
11	Et	R^2 = Et, $R^3 = R^4 = R^5 = H$	CH_3OH	$CDCl_3$	52	19/28[d]
12	Me	R^2 = Et, $R^3 = R^4 = R^5 = H$	$CHCl_3$	$CDCl_3$	55	17/28[d]
13	Et	$R^2 = R^5$ = Me, $R^3 = R^4 = H$	$CHCl_3$	$CDCl_3$	7	91
14	Et	$R^2 = R^5$ = Me, $R^3 = R^4 = H$	$CHCl_3$	CD_3OD	50	50
15	Et	$R^2 = R^5$ = Me, $R^3 = R^4 = H$	$CHCl_3$	DMSO-d_6	70	30
16	Me	$R^2 = R^5$ = Me, $R^3 = R^4 = H$	$CHCl_3$	$CDCl_3$	14	86
17	Et	$R^2 = R^3 = R^5 = H$, R^4 = Me	$CHCl_3$	$CDCl_3$	–	96
18	Me	$R^2 = R^3 = R^5 = H$, R^4 = Me	$CHCl_3$	$CDCl_3$	–	95
19	Et	$R^2 = R^5 = H$, $R^3 = R^4$ = Me	$CHCl_3$	$CDCl_3$	–	60/39[d]
20	Me	$R^2 = R^5 = H$, $R^3 = R^4$ = Me	$CHCl_3$	$CDCl_3$	–	76/15[d]

[a] The reactions were carried out at 22°C (reaction time 1 h).
[b] In dry solvent.
[c] Without binding of H_2O.
[d] Ratio of diastereoisomers.

(Scheme 1). The reaction was monitored by GC–MS and ^1H and ^{13}C NMR; the imino group was readily distinguished by the presence of an ^1H signal at δ 7.7 ppm, while oxazolidine ring was detected by a singlet from the 2-H proton which appeared at about δ 4.7 ppm. The experimental error in the measurement of signal intensities was reduced by the use of approximately equal concentrations.

Insofar as the condensation is a reversible process, numerous methods for binding of the liberated water or its removal from the reaction mixture were proposed in order to increase the yield of oxazolidines (or imino alcohols) [13]. Usually, azeotropic distillation [10, 14] is used or drying agents (such as $MgSO_4$ [15] or molecular sieves [16, 17]) are added. While optimizing the conditions for formation of condensation products **III**/**IV** we have found that 2-alkoxypropenals readily react (always with heat evolution) with 2-aminoalkanols at room temperature and that the reaction is complete in 1 h. According to the ^1H NMR data, the overall yield of tautomers **III** and **IV** attains 89–100%. The reaction occurs in such a way in various solvents, including water (see table, run nos. 4, 9). The process is considerably accelerated by microwave irradiation. In this case, the condensation of aldehyde **Ia** with 2-aminoethanol (**IIa**) in CH_2Cl_2 is complete in 1–5 min.

It is essential that the condensation products give rise to a dynamic ring–chain tautomeric equilibrium **III** ⇄ **IV**. Only a few quantitative data are available from the literature on the dynamics of tautomeric transformations of oxazolidines [14, 16–20]. In most early studies, a little attention was given to analysis of the product structure, effects of solvent and temperature on the tautomeric equilibrium, and time necessary for the equilibrium to establish [13, 21]. We have found that the tautomerization process is fast (on the NMR time scale): presumably, the equilibrium establishes in a few seconds (cf. [14]). On the other hand, there are published data [18], according to which equilibration of the oxazolidine and imino alcohol tautomers requires 3.7 h.

The ratio of the open-chain and cyclic tautomers considerably changes, depending on the solvent polarity: the fraction of the former increases in going to more polar solvents. Stabilization of the open-chain form by polar solvents is explained by formation of a strong hydrogen bond invoving the hydroxy group [14, 18, 19]. The reaction of 2-ethoxypropenal (**Ia**) with 2-aminoethanol (**IIa**) without a solvent or in chloroform, methylene chloride, benzene, or methanol, in the absence and in the presence of 4Å molecular sieves generally afforded a mixture of tautomers **IIIa** and **IVa** at a ratio of 5:1 to 3:1, depending on the conditions. As a rule, before recording the ^{1}H NMR spectrum, the liberated water was bound with $MgSO_4$, the solution was evaporated, and the residue was dissolved in $CDCl_3$. In order to elucidate the effect of the solvent polarity on the product ratio, the reaction was carried out in different solvents (see table). In anhydrous $CDCl_3$, the ratio **IIIa**:**IVa** was 5:1, whereas in methanol-d_4, DMSO-d_6, and D_2O only acyclic isomer **IIIa** was detected (run nos. 2–4). The reaction mixture obtained from 2-methoxypropenal (**Ib**) and 2-aminoethanol (**IIa**) in the presence of 4Å molecular sieves (run no. 6) contained tautomers **IIIb** and **IVb** at a ratio of 3:1 (in $CDCl_3$). In the absence of dehydrating agent, this ratio was 12.5:1 (run no. 5). We can conclude that even very small amount of water in the solvent strongly affects the state of tautomeric equilibrium. In methanol-d_4, DMSO-d_6, and D_2O only acyclic isomer **IIIb** was formed (run nos. 7–9).

Alkyl substitution leads to considerable increase in the fraction of ring tautomers **IVc**–**IVf** (run nos. 10–13, 16). However, even alkyl-substituted oxazolidine **IVe** is converted to an appreciable extent into the corresponding imino alcohol **IIIe** in going from $CDCl_3$ to more polar solvents (run nos. 13–15). The tautomer ratio **IIIe**:**IVe** changes from 1:13 in $CDCl_3$ to 1:1 in CD_3OD and 7:3 in DMSO-d_6). According to the ^{1}H NMR data, the ratio **IIIe**:**IVe** in CD_3OD did not change in 15 days. Compounds **IIIc**/**IVc** and **IIId**/**IVd** give rise to a three-component equilibrium, for the cyclic tautomer is a mixture of two diastereoisomers. No appreciable diastereoselectivity was observed in $CDCl_3$.

The reaction of 2-alkoxypropenals with N-alkyl-substituted 2-amino alcohols **IId** and **IIe** resulted in formation of 91 to 99% of stable N-substituted oxazolidines **IVg**–**IVj** which can be stored for a long time (run nos. 17–20).

It was also interesting to examine the effect of temperature on the tautomeric equilibrium. As noted previously [22], the condensation product obtained from 3-ethyl-2-hexenal and 2-amino-3-methyl-1-butanol clearly showed a tendency for the tautomeric equilibrium to shift toward the imino alcohol structure on raising the temperature [22]. We examined the temperature dependence of the tautomeric equilibrium with oxazolidine **IVe** by ^{1}H NMR spectroscopy. For this purpose. a mixture of isomers **IIIe** and **IVe** in $CDCl_3$ (ratio 1:17) was placed in an NMR ampule and heated for 10 min at 60°C. As a result, the fraction of acyclic tautomer **IIIe** considerably increased, and the ratio changed to 1:10. After cooling to 26°C, the initial tautomer ratio was restored. In another experiment, the same product was dissolved in DMSO-d_6, and the solution was heated from 28 to 80°C (two spectra were recorded at 1-min intervals) and cooled first to 50°C and then to 28°C. The ratio of tautomers **IIIe** and **IVe** remained unchanged (within experimental error) at all the above temperatures (7:3). These data suggest that heating for a short time does not induce displacement of the equilibrium.

EXPERIMENTAL

The ^{1}H and ^{13}C NMR spectra were recorded on a Bruker DPX-400 spectrometer at 400 (^{1}H) and 100.61 MHz (^{13}C); $CDCl_3$, DMSO-d_6, CD_3OD, and $CO(CD_3)_2$ were used as solvents, and HMDS, as internal reference. The IR spectra were measured on a Specord 75IR spectrometer. Gas chromatographic–mass spectrometric analysis was performed using an HP 5971A mass-selective detector (electron impact, 70 eV) coupled with an HP 5890 gas chromatograph (Ultra-2 column, 5% of phenylmethylsilicone; injector temperature 250°C; oven temperature 70 to 280°C at a rate of 20 deg/min).

Condensation of 2-alkoxypropenals Ia and Ib with 2-aminoalkanols IIa–IIe (*general procedure***).** Amino alcohol **IIa**–**IIf**, 25.2 mmol, was added to a solution of 25.2 mmol of 2-alkoxypropenal **Ia** or **Ib** in 5 ml of appropriate solvent. The mixture was left to stand for 1 h at 22°C, dried over $MgSO_4$, filtered from the drying agent, and evaporated under reduced pressure. The products were isolated by vacuum distillation. The yields were determined by ^{1}H NMR spectroscopy before distillation.

Reaction of 2-ethoxypropenal (Ia) with 2-aminoethanol (IIa). *a. In chloroform.* Yield 99.2%. Ratio **IIIa**:**IVa** 5:1. Yield 75% (after distillation), bp 112–113°C (3 mm), n_D^{22} = 1.4905. Mass spectrum, *m*/*z* (I_{rel}, %): 128 (14) $[M - Me]^+$, 114 (6) $[M - Et]^+$, 99 (77) $[M - OEt]^+$, 84 (85) $[M - NH(CH_2)_2O]^+$, 72 (78) $[CHNH(CH_2)_2O]^+$, 68 (72), 56 (100), 45 (47) $[OEt]^+$, 41 (45). IR spectrum, ν, cm^{-1}: 980, 1070, 1260, 1320,

1380, 1450, 1600 (C=N), 1650 (C=C), 2870, 2930, 2980, 3350 (OH). Found, %: C 58.25; H 9.40; N 9.24. $C_7H_{13}O_2N$. Calculated, %: C 58.72; H 9.15; N 9.78.

2-(1-Ethoxyvinyl)oxazolidine (IVa). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.32 t (3H, CH_3, J = 7.2 Hz], 3.03 d.d.d (1H, NCH_2, ^2J = 11.7, ^3J = 7.4 Hz), 3.295 d.d.d (1H, NCH_2, ^2J = 11.7, ^3J = 6.6, ^3J = 5.0 Hz), 3.72 d.d.d (1H, OCH_2, ^2J = 9.4, ^3J = 6.6, ^3J = 7.4 Hz), 3.78 d.d.d (1H, OCH_2, ^2J = 9.4, ^3J = 5.0, ^3J = 7.4 Hz), 4.1 d (1H, CH_2=, J = 2.3 Hz), 4.3 d (1H, CH_2=, J = 2.3 Hz, ^4J = 1.2 Hz), 4.77 s (1H, OCHN).

2-Ethoxy-3-(2-hydroxyethylimino)propene (IIIa). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.4 t (3H, CH_3, J = 7.0 Hz), 3.65 d.t (2H, NCH_2, J = 5.5 Hz, ^4J = 1.2 Hz), 3.86 t (2H, OCH_2, J = 5.5 Hz), 3.90 q [2H, OCH_2 (OEt), J = 7.0 Hz], 4.66 d (1H, CH_2=, J = 2.5 Hz), 4.67 d (1H, CH_2=, J = 2.5 Hz), 7.73 t (1H, CH=N, ^4J = 1.2 Hz).

b. In CD_3OD (without binding of water with $MgSO_4$). Only open-chain isomer **IIIa** was formed in 96.2% yield. ^{1}H NMR spectrum (CD_3OD), δ, ppm: 1.36 t (3H, CH_3, J = 7.0 Hz), 3.58 t (2H, NCH_2, J = 5.2 Hz), 3.78 t (2H, OCH_2, J = 5.2 Hz), 3.88 q (2H, OC**H**$_2$CH$_3$, J = 7.0 Hz), 4.66 d (1H, CH_2=, J = 2.5 Hz), 4.78 d (1H, CH_2=, J = 2.5 Hz), 7.73 s (1H, CH=N).

c. In D_2O. Only open-chain isomer **IIIa** was formed in 100% yield. ^{1}H NMR spectrum (D_2O), δ, ppm: 1.25 t (3H, CH_3, J = 7.0 Hz), 3.52 t (2H, NCH_2, J = 5.2 Hz), 3.71 t (2H, OCH_2, J = 5.2 Hz), 3.83 q (2H, OC**H**$_2$CH$_3$, J = 7.0 Hz), 4.66 d (1H, CH_2=, J = 2.5 Hz), 4.82 d (1H, CH_2=, J = 2.5 Hz), 7.68 s (1H, CH=N).

d. In DMSO-d_6 (both with and without binding of water). Only open-chain isomer **IIIa** was formed. ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 1.27 t (3H, CH_3, J = 7.0 Hz), 3.58 t (2H, NCH_2, J = 5.4 Hz), 3.78 t (2H, OCH_2, J = 5.4 Hz), 3.79 q (2H, OC**H**$_2$CH$_3$, J = 7.0 Hz), 4.62 d (1H, CH_2=, J = 2.5 Hz), 4.63 d (1H, CH_2=, J = 2.5 Hz), 7.66 s (1H, CH=N). ^{13}C NMR spectrum (DMSO-d_6), δ, ppm: 14.30 (CH_3), 60.56 (NCH_2), 62.94 (CH_2OH), 63.12 (O**C**H$_2$CH$_3$), 93.63 (=CH_2), 157.42 (OC=), 158.79 (CH=N).

e. 2-Aminoethanol (**IIa**), 0.059 g (0.97 mmol), and 4Å molecular sieves, 0.1 g, were added to a solution of 0.097 g (0.97 mmol) of 2-ethoxypropenal (**Ia**). The mixture was irradiated for 5 min in a microwave oven at a power of 300 W. According to the ^{1}H NMR spectrum ($CDCl_3$), the ratio of tautomers **IIIa** and **IVa** was 5:1; yield 99%.

e. An analogous experiment was carried out in CH_2Cl_2 in the presence of 0.14 g of 4Å molecular sieves and 8.3 mg (5 mol %) of *p*-toluenesulfonic acid. According to the ^{1}H NMR spectrum ($CDCl_3$), the overall yield of tautomers **IIIa** and **IVa** (3:1) was 100% in 1 min.

The reaction of 2-methoxypropenal (Ib) with 2-aminoethanol (IIa) was performed following the above general procedure.

a. In chloroform. Yield 99.45% (before distillation). The product was a mixture of isomers **IIIb** and **IVb** at a ratio of 1:0.08. After distillation, yield 25%, bp 90°C (3 mm), n_D^{22} = 1.4780. Mass spectrum, m/z (I_{rel}, %): 129 (5) $[M]^+$, 114 (5) $[M - CH_3]^+$, 98 (100) $[M - OCH_3]^+$, 83 (90), 68 (77), 55 (48), 42 (64), 29 (95).

2-(1-Methoxyvinyl)oxazolidine (IVb). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 3.50 t (1H, NCH_2, ^2J = 5.2 Hz), 3.67 s (3H, OCH_3), 3.81 t (2H, OCH_2, ^2J = 5.3 Hz), 4.13 d (1H, CH_2=, J = 2.5 Hz), 4.32 d (1H, CH_2=, J = 2.5 Hz), 4.8 s (1H, OCHN).

3-(2-Hydroxyethylimino)-2-methoxypropene (IIIb). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 3.61 t (2H, NCH_2, J = 5.2 Hz), 3.66 s (3H, OCH_3), 3.81 t (2H, OCH_2, J = 5.2 Hz), 4.56 d (1H, CH=, J = 2.6 Hz), 4.69 d (1H, CH=, J = 2.6 Hz), 7.71 s (1H, CH=N).

b. In CD_3OD (without removal of water). Yield of open-chain isomer **IIIb** 99.45%. ^{1}H NMR spectrum (CD_3OD), δ, ppm: 3.55 t (2H, NCH_2, J = 5.6 Hz), 3.66 s (3H, OCH_3), 3.73 t (2H, OCH_2, J = 5.6 Hz), 4.68 d (1H, CH_2=, J = 2.5 Hz), 4.81 d (1H, CH_2=, J = 2.5 Hz), 7.74 s (1H, CH=N). ^{13}C NMR spectrum (CD_3OD), δ, ppm: 55.62 (OCH_3), 62.33 (NCH_2), 63.36 (OCH_2), 95.75 (=CH_2), 159.25 (OC=), 161.60 (CH=N).

c. In D_2O. Only open-chain isomer **IIIb** was formed in 100% yield. ^{1}H NMR spectrum (D_2O), δ, ppm: 3.50 t (2H, NCH_2, J = 5.5 Hz), 3.59 s (3H, OCH_3), 3.70 t (2H, OCH_2, J = 5.5 Hz), 4.68 d (1H, CH_2=, J = 2.6 Hz), 4.84 d (1H, CH_2=, J = 2.6 Hz), 7.70 s (1H, CH=N).

d. In DMSO-d_6 (without binding of water). Yield of isomer **IIIb** 100%. ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 1.27 t (3H, CH_3, J = 7.0 Hz), 3.49 t (2H, NCH_2, J = 5.5 Hz), 3.57 s (3H, OCH_3), 3.58 t (2H, OCH_2, J = 5.5 Hz), 4.65 d (1H, CH_2=, J = 2.2 Hz), 4.69 d (1H, CH_2=, J = 2.2 Hz), 7.69 s (1H, CH=N).

Reaction of 2-ethoxypropenal (Ia) with 2-aminobutanol (IIb). *a*. The reaction was carried out in $CDCl_3$ following the general procedure, but no drying agent was added. Overall yield of isomers **IIIc** and

IVc 98.5%; ratio **IIIc**:**IVc**:**IVc′** 1:0.3:0.7. Yield 63.6% (after distillation), bp 105°C (4 mm), n_D^{22} = 1.4804. Mass spectrum (all isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 171 (1) $[M]^+$, 156 (9) $[M - CH_3]^+$, 142 (5) $[M - CH_2CH_3]^+$, 127 (22), 112 (100), 100 (86) $[M - CH_2{=}COCH_2CH_3]^+$, 96 (57), 84 (44), 55 (27), 42 (24).

2-(1-Ethoxyvinyl)-4-ethyloxazolidine (IVc) (first diastereoisomer). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.99 t (3H, CH_3, Et, *J* = 7.4 Hz), 1.31 t (3H, CH_3, OEt, *J* = 7.0 Hz), 1.52 m (2H, CH_2, Et), 3.2 m (1H, CH), 3.79 m (2H, OCH_2), 3.92 q (2H, OCH_2, Et, *J* = 7.0 Hz), 4.10 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.32 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.79 s (1H, NCHO).

2-(1-Ethoxyvinyl)-4-ethyloxazolidine (IVc′) (second diastereoisomer). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.95 (3H, CH_3, Et, *J* = 7.4 Hz), 1.31 t (3H, CH_3, OEt, *J* = 7.1 Hz), 1.52 m (2H, CH_2, Et), 3.20 m (1H, CH), 3.61 m (2H, OCH_2), 3.92 q (2H, OCH_2, Et, *J* = 7.0 Hz), 4.07 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.29 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.84 s (1H, NCHO).

2-Ethoxy-3-(1-hydroxymethylpropylimino)propene (IIIc). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.83 t (3H, CH_3, Et, *J* = 7.5 Hz), 1.38 t (3H, CH_3, OEt, *J* = 7.0 Hz), 1.52 m (2H, CH_2, Et), 3.34 m (1H, CH), 3.78 q (2H, OCH_2, Et, *J* = 7.0 Hz), 4.54 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.57 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 7.69 s (1H, CH=N). Found (for isomer mixture), %: C 63.17; H 10.07; N 8.22. $C_9H_{17}O_2H$. Calculated, %: C 63.13; H 10.01; N 8.18.

b. The reaction of aldehyde **Ia** with amino alcohol **IIb** was carried out in methanol without a drying agent. Evaporation of the solvent afforded 99% of a mixture of isomers **IIIc**, **IVc**, and **IVc′** at a ratio of 1:0.33:0.50.

Reaction of aldehyde (Ib) with 2-aminobutanol (IIb). The reaction was carried out following the general procedure, in $CDCl_3$ without binding of water. Overall yield 100%; the ratio of products **IIId**, **IVd**, and **IVd′** was 1:0.33:0.50. After distillation, yield 63.2%; bp 104°C (4 mm), n_D^{22} = 1.4770. Mass spectrum (all isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 157 (1) $[M]^+$, 142 (3) $[M - CH_3]^+$, 126 (100) $[M - OCH_3]^+$, 112 (17), 100 (63) $[M - CH_2{=}COCH_3]^+$, 84 (17), 57 (11) $[CH_2{=}COCH_3]^+$, 42 (26).

4-Ethyl-2-(1-methoxyvinyl)oxazolidine (IVd). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.00 t (3H, CH_3, *J* = 7.46 Hz), 1.59 m (2H, CH_2), 3.20 m (1H, CH), 3.61 s (3H, OCH_3), 3.71 m (2H, OCH_2), 4.15 d (1H, $CH_2{=}$, *J* = 2.57 Hz), 4.35 d (1H, $CH_2{=}$, *J* = 2.57 Hz), 4.81 s (1H, NCHO).

Stereoisomer IVd′. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.95 t (3H, CH_3, *J* = 7.46 Hz), 1.59 m (2H, CH_2), 3.04 m (1H, CH), 3.59 s (3H, OCH_3), 3.71 m (2H, OCH_2), 4.10 d (1H, $CH_2{=}$, *J* = 2.6 Hz), 4.33 d (1H, $CH_2{=}$, *J* = 2.6 Hz), 4.88 s (1H, NCHO).

3-(1-Hydroxymethylpropylimino)-2-metoxypropene (IIId). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.82 t (3H, CH_3, *J* = 7.46 Hz), 1.59 m (2H, C**H**$_2$CH$_3$), 3.69 s (3H, OCH_3), 3.71 m (2H, OCH_2), 4.57 d (1H, $CH_2{=}$, *J* = 2.6 Hz), 4.70 d (1H, $CH_2{=}$, *J* = 2.6 Hz), 7.71 s (1H, CH=N). Found (isomer mixture), %: C 60.55; H 10.00; N 9.13. $C_8H_{15}O_2H$. Calculated, %: C 61.12; H 9.62; N 8.91.

Reaction of 2-ethoxypropenal (Ia) with 2-amino-2-methylpropanol (IIc). The reaction was carried out following the general procedure without a drying agent. Overall yield 98%, ratio of isomers **IIIe** and **IVe** 0.08:1. After distillation, yield 56%, bp 98°C (15 mm), n_D^{22} = 1.4562. Mass spectrum (both isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 156 (5) $[M - CH_3]^+$, 140 (11), 126 (5) $[M - OCH_2CH_3]^+$, 112 (26), 100 (100) $[M - CH_2{=}COCH_2CH_3]^+$, 84 (33), 71 (1) $[CH_2{=}COCH_2CH_3]^+$, 55 (25), 42 (32). IR spectrum, ν, cm^{-1}: 960, 1060, 1105, 1245, 1290, 1380, 1460, 1590 (C=N), 1640 (C=C), 2865, 2970, 3310 br (OH).

2-(1-Ethoxyvinyl)-4,4-dimethyloxazolidine (IVe). ^{1}H NMR spectrum ($CDCl_3$), , ppm: 1.19 s (3H, CH_3), 1.31 t (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 3.34 d (1H, OCH_2, *J* = 7.2 Hz), 3.58 d (1H, OCH_2, *J* = 7.2 Hz), 3.80 q (2H, OC**H**$_2$CH$_3$, *J* = 7.0 Hz), 4.10 d (1H, $CH_2{=}$, *J* = 2.2 Hz), 4.33 d (1H, $CH_2{=}$, *J* 2.2 Hz), 4.89 s (1H, NCHO).

2-Ethoxy-3-(2-hydroxy-1,1-dimethylethylimino)-propene (IIIe). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.17 s (3H, CH_3), 1.36 t (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 3.90 q (2H, OC**H**$_2$CH$_3$, *J* = 7.0 Hz], 3.47 s (2H, OCH_2), 4.59 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.60 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 7.68 s (1H, CH=N). Found (isomer mixture), %: C 63.11; H 10.07; N 8.52. $C_9H_{17}O_2H$. Calculated, %: C 63.13; H 10.01; N 8.18.

A mixture of tautomers **IIIe** and **IVe** obtained in the above experiment was dissolved in $CDCl_3$, and the solution was placed in an NMR ampule and heated for 10 min at 60°C. The ratio of tautomers **IIIe** and **IVe** became 1:10. After cooling to 26°C, the initial tautomer ratio was restored. When the same tautomer mixture was heated in DMSO-d_6 for 1 min at 80°C and cooled first to 50°C and then to 28°C, the ratio of **IIIe** and **IVe** remained the same at all the above temperatures (7:3).

Reaction of 2-methoxypropenal (Ib) with 2-amino-2-methylpropanol (IIc). Following the

general procedure without a drying agent, a mixture of isomers **IIIf** and **IVf** (0.16:1) was formed in 100% yield (after distillation, 61.9%); bp 94°C (3 mm), n_D^{22} = 1.4620. Mass spectrum (both isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 157 (7) $[M]^+$, 142 (4) $[M - CH_3]^+$, 126 (56) $[M - OCH_3]^+$, 112 (56), 100 (100) $[M - CH_2{=}COCH_3]^+$, 80 (9), 73 (11) $[CH_2{=}COCH_2CH_3]^+$, 55 (40), 42 (49).

2-(1-Methoxyvinyl)-4,4-dimethyloxazolidine (IVf). ^{1}H NMR spectrum (CD_3OD), δ, ppm: 1.16 s (3H, CH_3), 1.26 s (3H, CH_3), 3.36 d (1H, OCH_2, *J* = 7.2 Hz), 3.54 d (1H, OCH_2, *J* = 7.2 Hz), 3.59 s (2H, OCH_3), 4.18 d (1H, $CH_2{=}$, *J* = 2.4 Hz), 4.35 d (1H, $CH_2{=}$, *J* = 2.4 Hz), 4.88 s (1H, NCHO).

3-(2-Hydroxy-1,1-dimethylethylimino)-2-methoxypropene (IIIf). ^{1}H NMR spectrum (CD_3OD), δ, ppm: 1.15 s (6H, CH_3), 3.66 s (2H, OCH_3), 3.42 s (2H, OCH_2), 4.67 d (1H, $CH_2{=}$, *J* = 2.5 Hz), 4.78 d (1H, $CH_2{=}$, *J* = 2.5 Hz), 7.74 s (1H, CH=N).

2-(1-Ethoxyvinyl)-3-methyloxazolidine (IVg) was synthesized from 2-ethoxypropenal (**Ia**) and 2-methylaminoethanol (**IId**) following the general procedure. Yield 96% (after distillation, 70%), bp 58°C (3 mm), n_D^{22} = 1.4560. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.32 t (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 2.41 s (3H, CH_3), 2.65 d.d.d [2H, NCH_2 (*ax*), ^2J = 9.6, ^3J = 7.2, ^3J = 7.1 Hz], 3.27 d.d.d [2H, NCH_2 (*eq*), ^2J = 9.6, ^3J = 6.6, ^3J = 4.3 Hz], 3.79 q (2H, OC**H**$_2$CH$_3$, *J* = 7.0 Hz), 3.92 d.d.d [2H, OCH_2 (*eq*), ^2J = 7.1, ^3J = 6.6, ^3J = 4.3 Hz], 3.97 d.d.d [2H, OCH_2 (*ax*), ^2J = 7.1, ^3J = 7.2 Hz, ^3J = 7.1 Hz], 4.06 d (1H, $CH_2{=}$, *J* = 2.0 Hz), 4.28 d (1H, $CH_2{=}$, *J* = 2.0 Hz), 4.24 s (1H, NCHO). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 14.21 (**C**H$_3$CH$_2$), 39.70 (CH_3), 54.09 (CH_2N), 63.29 (O**C**H$_2$CH$_3$), 65.22 (OCH_2), 84.01 ($CH_2{=}$), 96.60 (NCHO), 157.28 (C=). Mass spectrum, *m*/*z* (I_{rel}, %): 157 (5) $[M]^+$, 142 (1) $[M - CH_3]^+$, 128 (1) $[M - CH_2CH_3]^+$, 112 (1) $[M - OCH_2CH_3]^+$, 98 (12), 86 (100) $[M - CH_2{=}COCH_2CH_3]^+$, 58 (41), 42 (29). IR spectrum, ν, cm^{-1}: 970, 1060, 1145, 1240, 1305, 1450, 1625, 1700, 2780, 2970. Found, %: C 61.27; H 9.55; N 8.86. $C_8H_{15}NO_2$. Calculated, %: C 61.12; H 9.62; N 8.91.

2-(1-Methoxyvinyl)-3-methyloxazolidine (IVh) was synthesized from 2-methoxypropenal (**Ib**) and 2-methylaminoethanol (**IId**) following the general procedure. Yield 95% (after distillation, 52%), bp 45–46°C (2 mm), n_D^{22} = 1.4590. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 2.40 s (3H, CH_3H), 2.63 d.d.d [2H, NCH_2 (*ax*), ^2J = 9.5, ^3J = 7.7, ^3J = 6.7 Hz], 3.26 d.d.d [2H, NCH_2 (*eq*), ^2J = 9.5, ^3J = 6.7, ^3J = 3.9 Hz], 3.61 s (3H, OCH_3), 3.94 d.d.d [2H, OCH_2 (*eq*), ^2J = 7.3 Hz, ^3J = 6.7, ^3J = 3.9 Hz], 3.98 d.d.d [2H, OCH_2 (*ax*), ^2J = 7.3, ^3J = 7.7, ^3J = 6.7 Hz], 4.13 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.28 d (1H, $CH_2{=}$, *J* = 2.3 Hz), 4.21 s (1H, NCHO). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 39.31 (CH_3), 54.02 (CH_2N), 55.30 (OCH_3), 65.31 (OCH_2), 84.64 ($CH_2{=}$), 96.68 (NCHO), 160.01 (C=). Mass spectrum, *m*/*z* (I_{rel}, %): 143 (7) $[M]^+$, 128 (1) $[M - CH_3]^+$, 112 (1) $[M - OCH_3]^+$, 98 (19), 86 (100) $[M - CH_2{=}COCH_3]^+$, 58 (53), 42 (52). IR spectrum, ν, cm^{-1}: 1070, 1150, 1195, 1240, 1310, 1330, 1440, 1620, 1660, 1780, 2940. Found, %: C 58.72; H 9.15; N 9.78. $C_7H_{13}HO_2$. Calculated, %: C 58.27; H 9.03; N 9.93.

2-(1-Ethoxyvinyl)-3,5-dimethyloxazolidine (IVi) was synthesized from 2-ethoxypropenal (**Ia**) and 1-methylamino-2-propanol (**IIe**) following the general procedure. Yield 99% (after distillation, 52%), bp 98°C (15 mm), n_D^{22} = 1.4485, diastereoisomer ratio **IVi**:**IVi**′ = 3:2. Mass spectrum (both isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 171 (2) $[M]^+$, 156 (1) $[M - CH_3]^+$, 142 (1) $[M - CH_2CH_3]^+$, 100 (100) $[M - CH_2{=}COCH_2CH_3]^+$, 72 (42), 57 (8), 42 (28). IR spectrum, ν, cm^{-1}: 960, 1005, 1070, 1150, 1220, 1295, 1360, 1440, 1620, 1660 (C=C), 2780, 2960.

Isomer **IVi**. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.27 d (3H, CH_3CH, *J* = 6.1 Hz), 1.33 t (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 2.19 d.d (2H, NCH_2, *J* = 8.9 Hz), 2.37 s (1H, NCH_3), 3.35 d.d (1H, C**H**CH$_3$, *J* = 8.9 Hz), 3.79 q (3H, OC**H**$_2$CH$_3$, *J* = 7.0 Hz), 4.17 s (1H, NCHO), 4.30 d (1H, $CH_2{=}$, *J* = 2.0 Hz), 4.31 d (1H, $CH_2{=}$, *J* = 2.0 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 14.21 (**C**H$_3$CH$_2$), 19.24 (**C**H$_3$CH), 38.91 (NCH_3), 60.25 [OC**H**$_2$CH$_3$), 62.27 (CH_2N), 73.49 (**C**HCH$_3$), 84.41 ($CH_2{=}$), 96.41 (NCHO), 159.71 (C=).

Isomer **IV**′. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.30 d (3H, C**H**$_3$CH, *J* = 6.3 Hz), 1.32 (3H, C**H**$_3$CH$_2$, *J* = 7.0 Hz), 2.40 s (1H, NCH_3), 2.75 d.d (1H, NCH_2, *J* = 9.6 Hz), 2.90 d.d (1H, NCH_2, *J* = 9.6 Hz), 3.8 q (2H, OC**H**$_2$CH$_3$, *J* = 7.0 Hz), 4.06 d (1H, $CH_2{=}$, *J* = 1.9 Hz), 4.08 d (1H, $CH_2{=}$, *J* = 1.9 Hz), 4.24 d.d (1H, C**H**CH$_3$, *J* = 5.4 Hz), 4.28 s (1H, NCHO). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 14.27 (**C**H$_3$CH$_2$), 20.31 (**C**H$_3$CH), 39.95 (NCH_3), 60.25 (O**C**H$_2$CH$_3$), 63.21 (CH_2N), 72.36 (**C**HCH$_3$), 84.03 ($CH_2{=}$), 97.32 (NCHO), 160.24 (C=). Found, %: C 63.13; H 10.01; N 8.18. $C_9H_{17}NO_2$. Calculated, %: C 63.60; H 9.73; N 8.55.

2-(1-Methoxyvinyl)-3,5-dimethyloxazolidine (IVj) was synthesized from 2-methoxypropenal (**Ib**) and 1-methylamino-2-propanol (**IIe**) following the general procedure. Yield 91% (after distillation,

65.7%), bp 67°C (5 mm), n_D^{22} = 1.4507; stereoisomer ratio **IVj**:**IVj′** = 5:1. Mass spectrum (both isomers gave a single GC peak), *m*/*z* (I_{rel}, %): 157 (5) $[M]^+$, 142 (1), 128 (1), 100 (100) $[M - CH_2{=}COCH_3]^+$, 98 (39), 87 (1) $[M - CH_2{=}C(OCH_3)CH]^+$, 72 (72), 57 (21) $[CH_2{=}COCH_3]^+$, 42 (66). IR spectrum, ν, cm^{-1}: 895, 1005, 1070, 1160, 1220, 1310, 1380, 1445, 1625, 1660, 2780, 2960. Found, %: C 59.12; H 9.62; N 8.91. $C_8H_{15}O_2H$. Calculated, %: C 59.21; H 9.71; N 8.61.

Isomer **IVj**. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.27 d (3H, C**H**$_3$CH, *J* = 6.0 Hz), 2.18 d.d (1H, NCH_2, *J* = 9.0 Hz), 2.35 s (1H, NCH_3), 3.37 d.d (1H, C**H**CH_3, *J* = 8.6 Hz), 3.63 s (3H, OCH_3), 4.17 s (1H, NCHO), 4.33 d (1H, CH_2=, *J* = 2.2 Hz), 4.36 d (1H, CH_2=, *J* = 2.2 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 19.33 (**C**H_3CH), 38.65 (NCH_3), 55.41 (OCH_3), 62.33 (CH_2N), 73.77 (**C**HCH_3), 85.33 (CH_2=), 96.73 (NCHO), 160.11 (C=).

Isomer **IVj′**. ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 1.31 d (3H, C**H**$_3$CH, *J* = 6.1 Hz), 2.38 s (1H, NCH_3), 2.73 d.d (1H, NCH_2, *J* = 9.2 Hz), 2.90 d.d (1H, NCH_2, *J* = 9.2 Hz), 3.61 s (3H, OCH_3), 4.12 d (1H, CH_2=, *J* = 2.2 Hz), 4.15 d (1H, CH_2=, *J* = 2.2 Hz), 4.25 s (1H, NCHO), 4.33 d.d (1H, C**H**CH_3, *J* = 5.9 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ_C, ppm: 20.59 (**C**H_3CH), 39.81 (NCH_3), 55.53 (OCH_3), 60.27 (CH_2N), 72.48 (**C**HCH_3), 84.62 (CH_2=), 97.52 (NCHO), 161.3 (C=).

This study was financially supported by the Russian Foundation for Basic Research (project no. 03-03-33143).

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