Beside the starch isolated from the insoluble residue discussed above, we paid attention also to the material which was extracted together with the mucilage, but precipitated during evaporation and dialysis of the extract. We found that it was a mixture of the smallest pasty starch granules and other compounds, including colour materials. Separation of starch from this mixture is not effective.

All solid residues of the studied medicinal plant represent a starch-containing material which deserves adequate utilization, *e.g.* in fermentation industry or in other suitable microbial processing.

The present investigation completed the knowledge on α-D-glucans occurring in the roots of marsh mallow by confirming the presence of reserve starch beside the moderately branched (1→6)-α-D-glucan resembling microbial dextrans [4].

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Preparation, Characterization, and Antimicrobial Activity of 3-Alkyl-5-decyloxymethyloxazolidines

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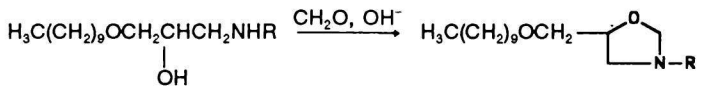
3-Alkyl-5-decyloxymethyloxazolidines were prepared by cyclocondensation of 1-alkylamino-3-decyloxy-2-propanols with formaldehyde. The structure of the synthesized compounds was proved by IR and mass spectral data. Antimicrobial efficiency of the prepared oxazolidines was also determined.

Derivatives of oxazolidines exhibiting bactericidal, fungicidal and virucidal activity were published mainly in the years 1969—1981. The most significant groups of the active derivatives are briefly summarized in the paper [1]. The earlier publications about oxazolidines and their properties are summarized in the work by *Bergmann* [2]. In the eightieth oxazolidines were used in the larger extent as herbicides [3—7] and herbicidal antidotes [8—11].

In the human medicine, oxazolidine derivatives are applied as β-adrenergic inhibitors [12—14]. However, this effect is probably due to alkanolamines formed from oxazolidines by hydrolysis in the organism.

In our previous papers [1, 15—17] we have studied oxazolidines with alkyl chain in the position 3. This paper deals with a new type of oxazolidine derivative having long alkoxymethyl chain in the position 5. For their synthesis, we started from 1-alkylamino-3-decyloxy-2-propanols *I* which afforded required oxazolidines (*II*) by cyclization reaction with formaldehyde in the alkaline medium (Scheme 1). Ethanol and water were used as a solvent.

Alkanolamines *I* were prepared by the reaction of decyloxymethyloxirane with short-chain



Scheme 1

aliphatic primary amines in methanol. Their survey is given in Table 1. These compounds are white crystalline products (excepting *Ig*) and their salts with hydrogen chloride are freely soluble in water under strong foaming. Mass spectra (12 eV) of all compounds exhibited the peak of molecular ion $M^{+\cdot}$ Moreover, the peaks corresponding to the following characteristic fragmentations were observed in the spectra: A = $[M^{+\cdot} - \dot{C}H_3]^+$ (only in the case of branched R, *i.e. Id*, *If*, and *Ig*), B = $[M^{+\cdot} - \dot{C}H_2OH]^+$ (for *Ih* and *Ii*), C = $[CH_3(CH_2)_9OCH_2CH(OH)CH_2NHCH_2]^+$, D = $[M^{+\cdot} - \dot{C}H_2(CH_2)_7CH_3]^+$, E = $[M^{+\cdot} - \dot{C}H_2O(CH_2)_9CH_3]^+$, F = $[M^{+\cdot} - \dot{C}H(OH)CH_2O(CH_2)_9CH_3]^+$. In all cases, the peak corresponding to the ion E exhibited the highest intensity. In the IR spectra, characteristic absorption bands were registered in the following regions: $\tilde{\nu}$ = 3307—3315 cm^{-1} ν(R—NH—R), $\tilde{\nu}$ = 1213—1226 cm^{-1} ν(C—N), $\tilde{\nu}$ = 1121—1129 cm^{-1} and 1072—1078 cm^{-1} ν(C—O—C), $\tilde{\nu}$ = 1107—1116 cm^{-1} ν(C—O) of secondary alcohols, $\tilde{\nu}$ = 1046 and 1048 cm^{-1} (for *Ih* and *Ii*) ν(C—O) of primary alcohols, $\tilde{\nu}$ = 738—740 cm^{-1} δ(CH_2) in —$(CH_2)_n$—O—, $\tilde{\nu}$ = 1252 cm^{-1} (for *Ig*) skeletal vibration for $(CH_3)_3C$—, and $\tilde{\nu}$ = 1167 and 1170 cm^{-1} (for *Id* and *If*) skeletal vibrations for $(CH_3)_2CH$—.

The prepared oxazolidines (*II*) are summarized in Table 2. These compounds are colourless, viscous and undistillable oils, well soluble in ethanol, acetone, chlorinated hydrocarbons, and nonpolar solvents, insoluble in water. In all mass spectra molecular peak $M^{+\cdot}$ was observed. Further peaks were assigned to the following fragmentations: A = $[M^{+\cdot} - \dot{C}H_3]^+$ (all derivatives besides *IIa*), B = $[M^{+\cdot} - \dot{C}H_2OH]^+$ (for *IIh* and *IIi*), C = $[M^{+\cdot} - (RCH_2)^{\cdot}]^+$, D = $[M^{+\cdot} - \dot{C}H_2(CH_2)_7CH_3]^+$, E = $[M^{+\cdot} - \dot{C}H_2(CH_2)_8CH_3]^+$, F = $[M^{+\cdot} - \dot{O}CH_2(CH_2)_8CH_3]^+$ The highest intensity was exhibited by those peaks corresponding to the ions C. In the IR spectra skeletal vibrations of oxazolidine ring were observed in the region of $\tilde{\nu}$ = 1161—1167, 1118—1120, and 1080—1082 cm^{-1}. For all derivatives, a sharp absorption band at $\tilde{\nu}$ = 722 cm^{-1} was registered, which can be assigned to the vibration δ$(CH_2)_n$. Derivatives *IIh* and *IIi* showed vibration bands ν(C—O) of primary alcohols at $\tilde{\nu}$ = 1043 and 1050 cm^{-1} Absorption band corresponding to the skeletal vibration of $(CH_3)_2CH$— group was

Table 1. Characterization of the Prepared 1-Alkylamino-3-decyloxy-2-propanols

Compound	R	Formula	M_r	w_i(calc.)/% / w_i(found)/%			Yield	M.p.[a]	M.p.[b]
				C	H	N	%	°C	°C
Ia	CH_3	$C_{14}H_{31}NO_2$	245.41	68.52	12.73	5.71	84	40—42	71—72
				68.61	12.67	5.74			
Ib	CH_2CH_3	$C_{15}H_{33}NO_2$	259.44	69.45	12.82	5.40	90	42—43	90—91
				69.50	12.78	5.44			
Ic	$(CH_2)_2CH_3$	$C_{16}H_{35}NO_2$	273.46	70.28	12.90	5.12	85	41—42	102—104
				70.35	12.86	5.16			
Id	$CH(CH_3)_2$	$C_{16}H_{35}NO_2$	273.46	70.28	12.90	5.12	84	31—33	56—58
				70.39	12.81	5.18			
Ie	$(CH_2)_3CH_3$	$C_{17}H_{37}NO_2$	287.49	71.03	12.97	4.87	88	43—44	135—136
				71.11	12.89	4.90			
If	$CH_2CH(CH_3)_2$	$C_{17}H_{37}NO_2$	287.49	71.03	12.97	4.87	81	36—37	122—123
				71.15	12.84	4.93			
Ig	$C(CH_3)_3$	$C_{17}H_{37}NO_2$	287.49	71.03	12.97	4.87	76	Oil	43—45
				71.18	12.82	4.92			
Ih	CH_2CH_2OH	$C_{15}H_{33}NO_3$	275.44	65.41	12.08	5.08	87	55—57	–
				65.48	11.98	5.12			
Ii	$C(CH_2OH)_3$	$C_{17}H_{37}NO_5$	335.49	60.86	11.12	4.18	85	77—81	–
				60.92	11.08	4.22			

a) Free amine; *b*) ammonium chloride, very hygroscopic *Ih*, *Ii* not determined.

Table 2. Characterization of the Prepared 3-Alkyl-5-decyloxymethyloxazolidines

Compound	R	Formula	M_r	w_i(calc.)/% / w_i(found)/%			Yield
				C	H	N	%
IIa	CH_3	$C_{15}H_{31}NO_2$	257.42	69.99 69.87	12.14 12.21	5.44 5.38	85
IIb	CH_2CH_3	$C_{16}H_{33}NO_2$	271.45	70.80 70.75	12.25 12.29	5.16 5.09	90
IIc	$(CH_2)_2CH_3$	$C_{17}H_{35}NO_2$	285.47	71.53 71.46	12.36 12.42	4.91 4.87	94
IId	$CH(CH_3)_2$	$C_{17}H_{35}NO_2$	285.47	71.53 71.41	12.36 12.43	4.91 4.85	86
IIe	$(CH_2)_3CH_3$	$C_{18}H_{37}NO_2$	299.50	72.19 72.11	12.45 12.30	4.68 4.62	92
IIf	$CH_2CH(CH_3)_2$	$C_{18}H_{37}NO_2$	299.50	72.19 72.09	12.45 12.52	4.68 4.63	90
IIg	$C(CH_3)_3$	$C_{18}H_{37}NO_2$	299.50	72.19 72.04	12.45 12.53	4.68 4.62	82
IIh	CH_2CH_2OH	$C_{16}H_{33}NO_3$	287.45	66.86 66.79	11.57 11.61	4.87 4.83	88
IIi	$C(CH_2OH)_3$	$C_{18}H_{37}NO_5$	347.50	62.22 62.15	10.73 10.80	4.03 3.98	86

found only in the case of derivative *IIf* at $\tilde{\nu}$ = 1144 cm^{-1}. In the case of compound *IId* this absorption band was not observed.

Antimicrobial efficiency of 3-alkyl-5-decyloxymethyloxazolidines, expressed by the values of minimal inhibitory concentration (MIC), is given in Table 3. The tests were performed in ethanol. For comparison of efficiency, standard disinfectant – benzyldodecyldimethylammonium bromide (Ajatin) was used.

Against gram-positive bacteria (*Staphylococcus epidermidis, Staphylococcus aureus, Bacillus subtilis,* and *Streptococcus faecalis*), derivatives *IIc*, *IIe*, and *IIf* were the most effective (10 $\mu g\ cm^{-3}$). For gram-negative bacteria (*Escherichia coli, Pseudomonas aeruginosa, Salmonella typhimurium,*

Table 3. Antimicrobial Activity (MIC/($\mu g\ cm^{-3}$)) of 3-Alkyl-5-decyloxymethyloxazolidines

Compound	*Staphylococcus epidermidis*	*Staphylococcus aureus*	*Bacillus subtilis*	*Streptococcus faecalis*	*Escherichia coli*	*Pseudomonas aeruginosa*	*Salmonella typhimurium*	*Shigella flexneri*
IIa	10	100	100	100	100	100	100	100
IIb	10	100	100	100	100	100	100	100
IIc	10	10	100	10	1000	100	1000	100
IId	10	100	100	100	1000	1000	1000	100
IIe	10	10	10	10	1000	100	100	10
IIf	10	10	10	100	1000	1000	1000	100
IIg	100	100	100	100	1000	1000	1000	100
IIh	100	100	100	100	100	100	100	100
IIi	100	100	100	100	1000	1000	1000	100
Ajatin	10	10	10	10	100	100	10	100

Table 3 (Continued)

Compound	*Candida albicans*	*Saccharomyces cerevisiae*	*Microsporum gypseum*	*Epidermaphyton floccosum*	*Trichophyton terrestre*	*Penicillium chrysogenum*	*Aspergillus fumigatus*	*Enterobacter aerogenes*
IIa	1000	1000	100	100	10	10	100	100
IIb	1000	1000	100	100	10	100	100	100
IIc	100	100	100	100	10	100	100	100
IId	1000	1000	100	100	10	100	100	1000
IIe	100	100	100	100	10	100	100	100
IIf	100	100	100	10	10	10	10	1000
IIg	1000	1000	100	100	100	100	100	1000
IIh	1000	1000	100	100	10	100	1000	100
IIi	1000	1000	100	100	10	100	1000	1000
Ajatin	10	100	10	100	10	100	100	1000

Shigella flexneri, and *Enterobacter aerogenes*), derivatives having nonbranched alkyl in the position 3 (*IIa*, *IIb*, *IIe*, *IIh*) were the most effective. In this case, the highest efficiency reached 100 μg cm^{-3}. Derivatives *IIc*, *IIe*, and *IIf* exhibited the same efficiency against yeasts *Candida albicans* and *Saccharomyces cerevisiae*. Against fibrous fungi *Microsporum gypseum, Epidermaphyton floccosum, Trichophyton terrestre, Penicillium chrysogenum,* and *Aspergillus fumigatus*, the efficiency was 10 and 100 μg cm^{-3} in most cases. Derivative *IIa* was found to be the most effective. Generally, derivatives with hydroxyalkyl group in the position 3 (*IIh* and *IIi*) and compounds having branched alkyl in the position α to the nitrogen atom of oxazolidine ring (*IId* where R = isopropyl and *IIg* where R = *tert*-butyl), exhibited low activity. Derivative *IIe* (R = butyl) exhibiting the broadest spectrum of efficiency is comparable with Ajatin. Unlike the Ajatin, *IIe* is well soluble in nonpolar solvents, which determines its application, *e.g.* in cosmetic and pharmacy (creams, emulsions, powders, *etc.*).

EXPERIMENTAL

Mass spectra (12 eV) were measured on a Jeol JMS-100D spectrometer at an emission current of 300 μA, applying direct sample-introduction technique. IR spectra (liquid film) were obtained on a Perkin—Elmer G-983 instrument and elemental analyses were performed on a Perkin—Elmer 240 analyzer.

MIC was determined by using dilution suspension method on solid cultivation media in ethanol according to the procedure described previously [18].

Decyloxymethyloxirane

A mixture of NaOH (50 % aqueous solution, 400 cm^3), chloromethyloxirane (295.3 g; 3.2 mol), and tetrabutylammonium hydrogen sulfate (8.4 g) is stirred at room temperature for 20 min. Then 1-decanol (94.8 g; 0.6 mol) was added in the course of 30 min. During this addition, the mixture was cooled by ice to keep temperature below 25 °C. After 4 h the reaction mixture was poured into ice water (2 dm^3). Organic layer was separated and aqueous layer was extracted with ether (3 x 200 cm^3). Combined extracts and organic layer were washed with saturated NaCl solution until neutral to litmus. Ethereal solution was dried over Na_2SO_4, solvent evaporated and the residue was distilled at 91 °C/10 Pa giving 110 g (85 %) of product.

1-Alkylamino-3-decyloxy-2-propanols *I*

Primary amine (0.5 mol) was dissolved in ethanol (100 cm^3) and decyloxymethyloxirane (102.7 g; 0.48 mol) was added. Then water (10 cm^3) was added as catalyst and the mixture was heated under reflux for 6 h. After cooling, ethanol was distilled off under diminished pressure. Resulting 1-alkylamino-3-decyloxy-2-propanols were crystallized from ethanol—ether. The yields were about 85 %.

3-Alkyl-5-decyloxymethyloxazolidines *II*

To compound *I* (1 mol) dissolved in ethanol (200 cm^3), KOH (5.6 g; 0.1 mol) dissolved in water (100 cm^3) and formaldehyde (150 cm^3 of 35 % aqueous solution) were added. The mixture was stirred for 8 h, diluted with ether (300 cm^3) and washed with water. After drying over Na_2SO_4, solvents were distilled off under diminished pressure. Reaction product was purified on a column of silica gel using a mixture of ethyl acetate—heptane (φ_r = 3 : 2) as an eluent yielding up to 94 % of product.

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Synthesis of Some Biologically Active Derivatives of 2-Hydroxymethyl-5-hydroxy-4*H*-pyran-4-one
II.* Synthesis and Biological Properties of *S*-Substituted 2-Thiomethyl-5-*O*-acyl Derivatives

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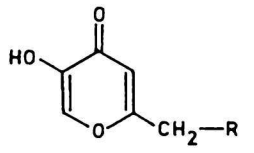
S-Substituted 2-thiomethyl-5-*O*-acyl-4*H*-pyran-4-ones were prepared by substituting bromine of 2-bromomethyl-5-hydroxy-4*H*-pyran-4-one by sulfur-containing nucleophiles and following acylation of the phenolic group. Products of this synthesis were active against bacteria and yeast and stimulate the growth of plants.

Kojic acid (2-hydroxymethyl-5-hydroxy-4*H*-pyran-4-one) reveals various pesticidal properties [1]. Our preceding paper concerned the preparation of a series of 5-*O*-acyl derivatives exhibiting interesting herbicidal and growth-regulating properties [2]. This paper presents a modification of the 2-hydroxymethyl group of some selected 5-*O*-acyl derivatives with the aim to investigate the change in transport properties in a biological system.

The substituted 2-thiomethyl-5-hydroxy-4*H*-pyran-4-ones (*I*; see formulas and Table 1) were obtained from 2-bromomethyl-5-hydroxy-4*H*-pyran-4-one (*Ia*) by displacement reaction with thiols [3—5]. Thus, 2-bromomethyl derivative *Ia* afforded on treatment with sodium salts of the respective thiols in an organic solvent (tetrahydrofuran, dimethylformamide) the corresponding sulfides *Ib—Ii*. Heteroaryl sulfides *Ij—In* were reacted in aqueous ethanol in the presence of potassium hydroxide. The 2-sulfomethyl derivative *Io* was synthesized from 2-bromomethyl derivative *Ia* and sodium sulfite.

Sommelet—Hauser rearrangement [6] is used for skeletal modification of 4*H*-pyran-4-one into 3-methylthiomethyl derivatives, but only 2-methylthiomethyl derivative *Ib* and unidentified tars instead of the expected compounds *IIIa*, *IIIb* were obtained when reacting 5-*O*-acylkojates with dimethyl sulfide.



I

R	
a	Br
b	CH_3S
c	$(CH_3)_2CHS$
d	$CH_3(CH_2)_2S$
e	$CH_3(CH_2)_4S$
f	$CH_3(CH_2)_7S$
g	$C_2H_5OCOCH_2S$
h	$HO(CH_2)_2S$
i	cyclohexylthio
j	2-methyl-1,3,4-thiadiazol-5-ylthio
k	2-benzimidazolylthio
l	2-benzthiazolylthio
m	2-pyridylthio
n	2-pyridylthio *N*-oxide
o	SO_3Na

* For Part *I* see *Collect. Czechoslov. Chem. Commun. 55,* 833 (1990).

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