

MAGDALENA RUCKA\*, MAŁGORZATA OŚWIĘCIMSKA\*\*, STANISŁAW WITEK\*\*\*

## NEW BIOCIDES FOR COOLING WATER TREATMENT\*\*\*

### II. ALKOXYMETHYLENEAMMONIUM CHLORIDES

The present paper is a continuation of the search for new biocides against biological slimes in industrial cooling systems [2]. The examined 104 alkoxyethyleneammonium chlorides have shown strong inhibitory effects with respect to algae (*Oscillatoria* sp.) and bacteria (*Sphaerotilus natans*). It has been found that there exists a relationship between chemical structure and biological activity of the compounds investigated.

#### 1. INTRODUCTION

The problem of biological slime control in cooling systems was discussed in former paper [2], showing its importance in the industry and the shortage of efficient biocides. The biocidal activity of ammonium salts against filamentous algae and bacteria occurring in industrial cooling systems, and stated in former investigations [2], has inclined the authors to continue their research. The paper presents the results obtained for the group of alkoxyethyleneammonium chlorides whose strong fungicidal activity was stated earlier [3]. The above salts strongly influence the transport of ions across biological membranes causing their destruction even at very low concentrations [1]. Such properties allowed to expect that the examined group of chlorides should also show a strong biocidal activity against algae and bacteria forming biological slimes.

#### 2. MATERIAL AND METHODS

##### 2.1. ALKOXYMETHYLENEAMMONIUM SALTS

The results of biological tests performed with 104 alkoxyethyleneammonium chlorides and the structures of salts examined are presented in tabs. 1-8. The compounds were synthesized in I.O.T.P. laboratory by treating the selected tertiary amines, i. e. tri-

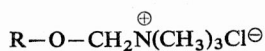
\* Institute of Civil and Environmental Engineering, Technical University of Rzeszów, 35-959 Rzeszów, ul. Pstrowskiego 13/I, Poland.

\*\* Institute of Organic Technology and Plastics, Technical University of Wrocław, 50-371 Wrocław, ul. Łukasiewicza 2, Poland.

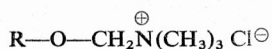
\*\*\* The present work is sponsored within the frame of the problem R.1.9. "Evolution of bio-regulator systems".

Table 1

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by alkoxymethylene-trimethylammonium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki alkoksymetyleno-trimetyloamoniowe



No. of compound	R	<i>Oscillatoria</i> sp.		<i>Sphaerotilus natans</i>		
		Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
1	C <sub>2</sub> H <sub>5</sub>	0.0	—	—	0.0	—
2	C <sub>3</sub> H <sub>7</sub>	24.0	0.0	—	0.0	—
3	C <sub>4</sub> H <sub>9</sub>	0.0	—	—	0.0	—
4	C <sub>5</sub> H <sub>11</sub>	0.0	—	—	0.0	—
5	C <sub>6</sub> H <sub>13</sub>	49.0	0.0	—	0.0	—
6	C <sub>7</sub> H <sub>15</sub>	63.0	0.0	—	0.0	—
7	C <sub>8</sub> H <sub>17</sub>	100.0	0.0	—	0.0	—
8	C <sub>9</sub> H <sub>19</sub>	100.0	0.0	—	70.0	46.0
9	C <sub>10</sub> H <sub>21</sub>	100.0	100.0	0.0	78.0	49.0
10	C <sub>12</sub> H <sub>25</sub>	100.0	100.0	0.0	74.0	70.0
11	C <sub>14</sub> H <sub>29</sub>	100.0	100.0	0.0	78.7	35.2
12	C <sub>16</sub> H <sub>33</sub>	100.0	100.0	0.0	81.5	31.5
13	C <sub>18</sub> H <sub>37</sub>	100.0	68.9	0.0	39.8	—

Chlorophyll — control value: 0.62 mg; biomass — control value: 10.0 mg.

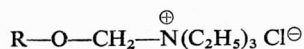
methylamine (tab. 1), triethylamine (tab. 2), dimethylcyclohexylamine (tab. 3), 4-methylpiperidine (tab. 4), 1,4-dimethylpiperazine (tab. 5), 4-methylmorpholine (tab. 6), 2,4,6-trimethylmorpholine (tab. 7), and 4-ethyl-2-oxomorpholine (tab. 8), with alkylchloromethyl ethers. The compounds investigated were of purity exceeding 98%; the details concerning the synthesis and properties of the obtained salts will be published elsewhere.

## 2.2. BIOLOGICAL TESTS

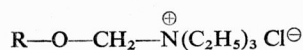
1. Bacteriocidal activities of the compounds investigated were tested on filiform *Sphaerotilus natans* isolated from biological slimes of the Wrocław Distillery cooling system. The increment in bacterial biomass was determined in nutrient solution supplemented with the biocide being tested. The detailed description of the procedure was given in [2].

Table 2

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by alkoxymethylene-triethylammonium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki alkoksymetyleno-trietyloamoniowe



No. of compound	R	Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		20.0	2.0	0.4	200	100
14	C <sub>2</sub> H <sub>5</sub>	11.0	—	—	0.0	—
15	C <sub>3</sub> H <sub>7</sub>	0.0	—	—	0.0	—
16	C <sub>4</sub> H <sub>9</sub>	6.0	—	—	0.0	—
17	C <sub>5</sub> H <sub>11</sub>	7.0	—	—	0.0	—
18	C <sub>6</sub> H <sub>13</sub>	0.0	—	—	0.0	—
19	C <sub>7</sub> H <sub>15</sub>	0.0	—	—	0.0	—
20	C <sub>8</sub> H <sub>17</sub>	7.0	—	—	0.0	—
21	C <sub>9</sub> H <sub>19</sub>	10.0	—	—	0.0	—
22	C <sub>10</sub> H <sub>21</sub>	100.0	0.0	—	25.0	—
23	C <sub>12</sub> H <sub>25</sub>	100.0	0.0	—	74.0	62.0
24	C <sub>14</sub> H <sub>29</sub>	100.0	72.0	0.0	75.2	38.0
25	C <sub>16</sub> H <sub>33</sub>	100.0	83.0	0.0	78.4	42.2
26	C <sub>18</sub> H <sub>37</sub>	100.0	65.0	0.0	42.6	—

Chlorophyll — control value: 0.62 mg; biomass — control value: 10.5 mg.

The inhibition percent (the mean from 5 replications given in tabs. 1–8) is referred to biomass in control samples (without biocide) assumed to be 100%.

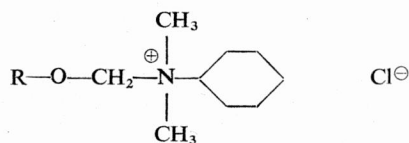
2. Algicidal activity of the compounds investigated was tested on blue-green algae *Oscillatoria* sp. isolated from biological slimes of the Krosno Glass Work cooling system. The chlorophyll content in algae growing in the presence of a biocide was determined according to the procedure described in details in [2]. The inhibition percent (the mean value from 5 replications) is referred to chlorophyll content in control samples (without biocide) assumed to be 100%.

### 3. RESULTS AND DISCUSSION

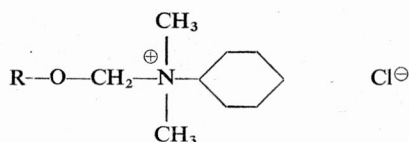
The performed biological tests have revealed a high algicidal activity of the examined ammonium salts (tabs. 1–6). According to expectations the maximum algicidal activity has been stated in salts possessing long alkyl radicals, ranging usually within C<sub>10</sub>–C<sub>16</sub>,

Table 3

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by N-alkoxymethylene-N,N-dimethylcyclohexylammonium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki N-alkoksymetyleno-N,N-dimetylocykloheksyloamoniowe



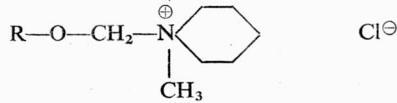
No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
27	C <sub>2</sub> H <sub>5</sub>	100.0	100.0	0.0	78.0	60.0
28	C <sub>3</sub> H <sub>7</sub>	27.0	0.0	—	0.0	—
29	C <sub>4</sub> H <sub>9</sub>	23.0	0.0	—	0.0	—
30	C <sub>5</sub> H <sub>11</sub>	19.0	—	—	0.0	—
31	C <sub>6</sub> H <sub>13</sub>	25.0	0.0	—	0.0	—
32	C <sub>7</sub> H <sub>15</sub>	22.0	0.0	—	0.0	—
33	C <sub>8</sub> H <sub>17</sub>	20.0	—	—	0.0	—
34	C <sub>9</sub> H <sub>19</sub>	13.0	—	—	0.0	—
35	C <sub>10</sub> H <sub>21</sub>	34.0	0.0	—	0.0	—
36	C <sub>12</sub> H <sub>25</sub>	100.0	0.0	—	35.0	—
37	C <sub>14</sub> H <sub>29</sub>	100.0	83.6	0.0	0.0	—
38	C <sub>16</sub> H <sub>33</sub>	100.0	74.7	0.0	56.5	—
39	C <sub>18</sub> H <sub>37</sub>	100.0	80.3	0.0	32.4	—

Chlorophyll — control value: 0.61 mg } arithmetical means  
 biomass — control value: 10.2 mg } from 5 replications.

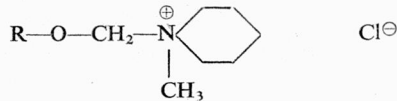
although the range varied for different groups of salts. Some deviations from this rule, e. g. the substances 27, 53, cannot be at yet explained. Similar relationship between the activity and the length of alkyl chain in the salts examined has been observed with respect to pathogenic fungi [3] and in studies of the effect of ammonium salts on ion transport across lysosome membranes [1]. Thus, it may be inferred that the operation principle of the investigated alkoxymethyleneammonium salts is not specific, as the said compounds act upon the biological membranes and on transport across these membranes. Detailed investigations in this respect are being conducted.

Table 4

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by N-alkoxymethylene-N-methylpiperidinium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki N-alkoksymetyleno-N-metylopiperydyniowe



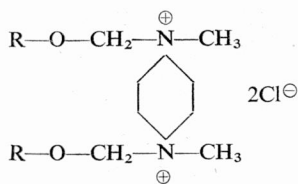
No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
40	C <sub>2</sub> H <sub>5</sub>	0.0	—	—	0.0	—
41	C <sub>3</sub> H <sub>7</sub>	26.2	13.1	—	0.0	—
42	C <sub>4</sub> H <sub>9</sub>	34.4	11.8	—	0.0	—
43	C <sub>5</sub> H <sub>11</sub>	29.3	10.6	—	0.0	—
44	C <sub>6</sub> H <sub>13</sub>	26.2	0.0	—	0.0	—
45	C <sub>7</sub> H <sub>15</sub>	100.0	78.5	0.0	27.8	—
46	C <sub>8</sub> H <sub>17</sub>	100.0	47.5	—	39.8	—
47	C <sub>9</sub> H <sub>19</sub>	93.0	40.6	—	46.0	—
48	C <sub>10</sub> H <sub>21</sub>	100.0	50.8	—	54.6	—
49	C <sub>12</sub> H <sub>25</sub>	100.0	100.0	0.0	74.1	19.4
50	C <sub>14</sub> H <sub>29</sub>	100.0	100.0	36.1	71.3	32.4
51	C <sub>16</sub> H <sub>33</sub>	100.0	100.0	0.0	52.8	—
52	C <sub>18</sub> H <sub>37</sub>	100.0	23.0	—	36.1	—

Chlorophyll — control value: 0.61 mg; biomass — control value: 10.2 mg.

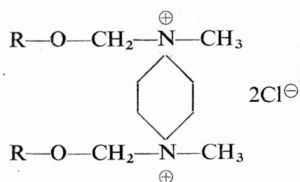
Of the discussed 6 groups of alkoxymethyleammonium salts 1–78 (tabs. 1–6) the lowest activity has been stated in bis-piperazinium (53–65) and triethylammonium (14–26) derivatives, while the trimethylammonium (1–13) and piperidinium (40–52) derivatives appeared to have the highest activity. The above fact combined with the influence of alkoxymethyleammonium salts on model membranes [1] allows to infer that trimethylammonium substituent, the volume of which is small, facilitates the penetration of long alkyl radicals into the membrane, leading thus to its destruction. On the other hand, the bis-piperazinium fragment, the volume of which is much larger, being stiffened by the ring, impedes the penetration of alkyl chains into the membrane. That is why its destruction and biological activity of the salt are observed only at its higher concentrations. The relatively low activity of triethylammonium derivatives 14–26 (tab. 2) and 2,4,6-trimethylmorpholinium derivatives 79–91 (tab. 7) may be similarly explained.

Table 5

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by 1,4-bisalkoxymethylene-1,4-dimethylpiperazinum dichlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez dichlorki 1,4-bisalkoksymetyleno-1,4-dimetylopiperazyniowe



No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentrations of tested dichlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
53	C <sub>2</sub> H <sub>5</sub>	100.0	37.7	—	0.0	—
54	C <sub>3</sub> H <sub>7</sub>	36.1	16.4	—	0.0	—
55	C <sub>4</sub> H <sub>9</sub>	0.0	—	—	0.0	—
56	C <sub>5</sub> H <sub>11</sub>	19.7	—	—	0.0	—
57	C <sub>6</sub> H <sub>13</sub>	41.0	4.9	—	37.0	—
58	C <sub>7</sub> H <sub>15</sub>	29.5	0.0	—	34.3	—
59	C <sub>8</sub> H <sub>17</sub>	100.0	100.0	0.0	40.7	—
60	C <sub>9</sub> H <sub>19</sub>	57.4	19.7	—	6.0	—
61	C <sub>10</sub> H <sub>21</sub>	100.0	29.5	—	30.6	—
62	C <sub>12</sub> H <sub>25</sub>	47.5	0.0	—	70.4	13.0
63	C <sub>14</sub> H <sub>29</sub>	100.0	93.3	0.0	60.0	—
64	C <sub>16</sub> H <sub>33</sub>	100.0	59.0	—	58.3	—
65	C <sub>18</sub> H <sub>37</sub>	100.0	68.9	—	33.3	—

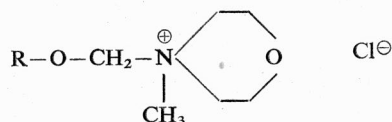
Chlorophyll — control value: 0.62 mg; biomass — control value: 10.5 mg.

It appeared that of the salts examined N-dodecyloxymethylene-N-methylpiperidinium chloride 50 (tab. 4) was the best algicide, as it was still efficient against *Oscillatoria* sp. at the concentrations as low as 0.4 mg/dm<sup>3</sup> ( $1.1 \times 10^{-6}$  M/dm<sup>3</sup>).

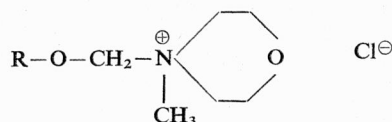
4-ethyl-2-oxomorpholinium salts (tab. 8) — though similar in structure to 4,4-diethyl-2-oxomorpholinium chloride characterized by a high algicidal activity — appeared to be practically inactive. It should be added, however, that 2-oxomorpholinium salts in water solutions are not stable being easily hydrolyzed into the corresponding betaines,

Table 6

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by 4-alkoxymethylene-4-methylmorpholinium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki 4-alkoksymetyleno-4-metylomorfoliniowe



No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
66	C <sub>2</sub> H <sub>5</sub>	0.0	—	—	0.0	—
67	C <sub>3</sub> H <sub>7</sub>	0.0	—	—	0.0	—
68	C <sub>4</sub> H <sub>9</sub>	0.0	—	—	62.0	52.0
69	C <sub>5</sub> H <sub>11</sub>	0.0	—	—	0.0	—
70	C <sub>6</sub> H <sub>13</sub>	15.0	0.0	—	34.0	—
71	C <sub>7</sub> H <sub>15</sub>	46.0	0.0	—	0.0	—
72	C <sub>8</sub> H <sub>17</sub>	100.0	0.0	—	0.0	—
73	C <sub>9</sub> H <sub>19</sub>	100.0	10.0	—	49.0	—
74	C <sub>10</sub> H <sub>21</sub>	100.0	0.0	—	9.0	—
75	C <sub>12</sub> H <sub>25</sub>	100.0	100.0	0.0	35.0	—
76	C <sub>14</sub> H <sub>29</sub>	100.0	100.0	0.0	78.7	27.8
77	C <sub>16</sub> H <sub>33</sub>	100.0	82.0	0.0	52.8	—
78	C <sub>18</sub> H <sub>37</sub>	100.0	23.0	—	21.3	—

Chlorophyll — control value: 0.62 mg; biomass — control value: 10.5 mg.

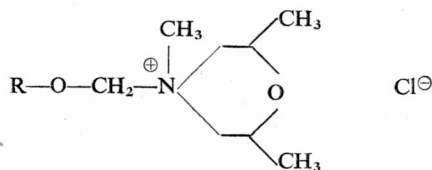
due to the opening of their rings [4]. Thus, it seems highly probably that the examined salts 92–104 form also in water the corresponding betaines. This hypothesis does not elucidate completely their inactivity, since 4,4-diethyl-2-oxomorpholinium chloride — though easily hydrolyzed to betaine — is nevertheless a strongly algicidal substance [2].

The group of 2,4,6-trimethylmorpholinium salts 79–91 (tab. 7) is practically inactive, the only exception being the substance 90 with a long alkyl chain (C<sub>16</sub>), the activity of which at the concentration of 2 mg/dm<sup>3</sup> is still pretty high.

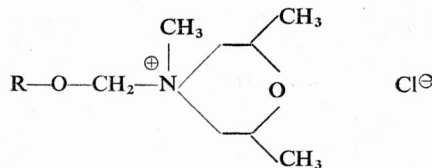
Similar relations have been also stated in testing the bacteriocidal activity against *S. natans*. In general, the compounds characterized by highly algicidal properties revealed also the highest bacteriocidal activities. The substance 10 which was the best bacteriocide was at the same time a good algicide (tab. 1). The compound 90 — the only active

Table 7

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by 4-alkoxymethylene-2, 4, 6-trimethylmorpholinium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki 4-alkoksymetyleno-2,4,6-trimetylmorfoliniowe



No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentrations of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
79	C <sub>2</sub> H <sub>5</sub>	0.0	—	—	0.0	—
80	C <sub>3</sub> H <sub>7</sub>	0.0	—	—	4.8	—
81	C <sub>4</sub> H <sub>9</sub>	3.3	—	—	0.0	—
82	C <sub>5</sub> H <sub>11</sub>	4.9	—	—	0.0	—
83	C <sub>6</sub> H <sub>13</sub>	0.0	—	—	8.6	—
84	C <sub>7</sub> H <sub>15</sub>	0.0	—	—	14.4	—
85	C <sub>8</sub> H <sub>17</sub>	0.0	—	—	0.0	—
86	C <sub>9</sub> H <sub>19</sub>	0.0	—	—	6.7	—
87	C <sub>10</sub> H <sub>21</sub>	3.3	—	—	0.0	—
88	C <sub>12</sub> H <sub>25</sub>	3.3	—	—	4.8	—
89	C <sub>14</sub> H <sub>29</sub>	4.9	—	—	0.0	—
90	C <sub>16</sub> H <sub>33</sub>	100.0	39.3	—	88.5	56.3
91	C <sub>18</sub> H <sub>37</sub>	0.0	—	—	0.0	—

Chlorophyll — control value: 0.62 mg; biomass — control value: 10.5 mg.

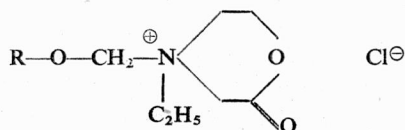
among 2,4,6-trimethylmorpholinium salts — appeared to be a relatively active bactericide. Fairly high activity was stated in some triethylammonium derivatives (23–25). The compounds tested were less active with respect to bacteria than to algae. An efficient inhibition of *S. natans* is achieved at the concentration as high as 100 mg/dm<sup>3</sup>, but even at 200 mg/dm<sup>3</sup> a total inhibition does not occur.

Summing up, the examined group of alkoxymethyleammonium salts should be recognized as a promising group of biocides. A good bacteriocidal activity and very high algicidal activity suggest that low doses of these compounds may be successfully applied to industrial cooling system without noxious effect on water biocenosis. A wide introduction of these biocides should be, however, preceded by investigations in which their toxicity and biodegradability have to be determined.

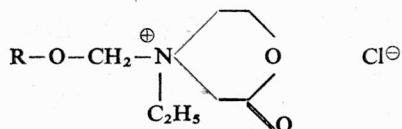


Table 8

Growth inhibition of algae (in % of chlorophyll content) and bacteria (in % of biomass) by 4-alkoxymethylene-4-methyl-2-oxomorpholinium chlorides



Hamowanie wzrostu glonów (w % zawartości chlorofilu) i bakterii (w % biomasy) przez chlorki 4-alkoksymetyleno-4-metylo-2-oksomorfoliniowe



No. of compound	R	<i>Oscillatoria</i> sp.			<i>Sphaerotilus natans</i>	
		Concentration of tested chlorides (mg/dm <sup>3</sup> )				
		20.0	2.0	0.4	200	100
92	C <sub>2</sub> H <sub>5</sub>	0.0	—	—	26.9	—
93	C <sub>3</sub> H <sub>7</sub>	0.0	—	—	34.5	—
94	C <sub>4</sub> H <sub>9</sub>	3.3	—	—	12.5	—
95	C <sub>5</sub> H <sub>11</sub>	4.9	—	—	0.0	—
96	C <sub>6</sub> H <sub>13</sub>	0.0	—	—	21.2	—
97	C <sub>7</sub> H <sub>15</sub>	0.0	—	—	13.5	—
98	C <sub>8</sub> H <sub>17</sub>	0.0	—	—	5.8	—
99	C <sub>9</sub> H <sub>19</sub>	0.0	—	—	48.1	—
100	C <sub>10</sub> H <sub>21</sub>	0.0	—	—	26.0	—
101	C <sub>12</sub> H <sub>25</sub>	0.0	—	—	28.8	—
102	C <sub>14</sub> H <sub>29</sub>	0.0	—	—	22.1	—
103	C <sub>16</sub> H <sub>33</sub>	3.3	—	—	18.3	—
104	C <sub>18</sub> H <sub>37</sub>	0.0	—	—	0.0	—

Chlorophyll — control value: 0.62 mg; biomass — control value: 10.5 mg.

## REFERENCES

- [1] GABRIELSKA J. et al., *Effect of alkyl chain length in alkoxymethyleammonium chlorides on ion transport across liposome membranes*, *Studia biophysica*, Vol. 82 (1981), No. 2, pp. 149–155.
- [2] RUCKA M. et al., *New biocides for cooling water treatment. I. Selected quarternary ammonium salts*, *Environ. Prot. Eng.*, Vol. 6 (1980), No. 4, pp. 455–464.
- [3] WITEK S. et al., Belg. Pat., No. 864781, 1978.
- [4] WITEK S., OŚWIĘCIMSKA M., *Formation of 4,4-dialkyl-2-oxomorpholinium chlorides*, *J. prakt. Chem.*, Vol. 322 (1980), No. 3, pp. 367–374.

## NOWE BIOCYDY W OCZYSZCZANIU UKŁADÓW CHŁODNICZYCH

### II. CHLORKI ALKOKSYMETYLENO-AMONIOWE

Praca niniejsza stanowi kontynuację prac poszukiwawczych nad nowymi biocydami do zwalczania mikroorganizmów tworzących obrosty biologiczne w przemysłowych układach chłodniczych [2]. Badano 104 chlorki alkoksymetyleno-amoniowe. Związki te wykazały silne działanie hamujące w stosunku do glonów *Oscillatoria* sp. oraz bakterii *Sphaerotilus natans*. Przedstawiono zależność między budową chemiczną a działaniem biologicznym badanej grupy związków.

## NEUE BIOZIDE ZUR REINIGUNG VON KÜHLWASSERSYSTEMEN

### II. ALKOXYMETHYLEN-AMMONIUMCHLORIDEN

Der vorliegende Bericht knüpft an eine vorangehende Arbeit der Verfasser [2] an. Hier wird über Versuche mit 104 verschiedenen Alkoxymethylen-Ammoniumchloriden berichtet. Diese Verbindungen hemmten das Wachstum von *Oscillatoria* sp. und *Sphaerotilus natans* sehr stark. Dargelegt wird die Beziehung zwischen der chemischen Struktur einerseits und der biologischen Wirkung einer bestimmten Gruppe der Verbindungen andererseits.

## НОВЫЕ БИОЦИДЫ В ОЧИСТКЕ СИСТЕМЫ ОХЛАЖДЕНИЯ

### II. ХЛОРИСТЫЕ АЛКОКСИМЕТИЛЕНАММОНИИ

Настоящая работа представляет собой продолжение поисковых работ над новыми биоцидами для борьбы с микроорганизмами, образующими биологические обrostы в промышленных системах охлаждения [2]. Было исследовано 104 хлористых алкоксиметиленаммония. Эти соединения выявили сильное тормозящее действие по отношению к водорослям *Oscillatoria* sp., а также к бактериям *Sphaerotilus natans*. Приведена зависимость между химическим строением и биологическим действием исследуемой группы соединений.