# Benzothiazole compounds
# XX. Synthesis of 3,4,6-substituted benzothiazolium salts as plant growth regulators and their antimicrobial activity

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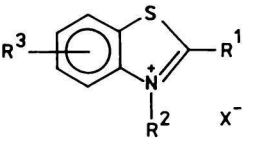
Substituted benzothiazolium salts have been prepared by treatment of 4-$CH_3$-, 4-Cl-, 6-$CH_3$-, and 6-Cl-benzothiazoles with reactive halogen derivatives or dimethyl sulfate. Their stimulation and inhibitory effects on plant growth and antimicrobial activity including the Free—Wilson analysis are described. The highest stimulation activity was found with 6-methyl-3--propoxycarbonylmethylbenzothiazolium bromide, the highest inhibitory activity with 4-chloro-3-methylbenzothiazolium bromide and 4-chloro-3--methylbenzothiazolium methyl sulfate. The synthesized compounds have not exhibited noticeable antimicrobial activity.

Синтезированы соли замещенных бензотиазолов посредством воздействия на 4-$CH_3$-, 4-Cl-, 6-$CH_3$- и 6-Cl-бензотиазолы реакционноспособными галогенпроизводными или диметилсульфатом. Описаны их стимулирующий и ингибирующий эффекты на рост растений, антимикробиальная активность, а также анализ Фри – Вильсона. Наивысшая стимулирующая активность была обнаружена у 6-метил-3-пропоксикарбонилметилбензотиазолийбромида, наивысшая ингибирующая активность у 4-хлор-3-метилбензотиазолийбромида и 4-хлор-3-метилбензотиазолийметилсульфата. Полученные соединения не проявляли заметной антимикробиальной активности.

Recently, further specific effects of benzothiazolium salts, for example increasing the sugar content in sugar-producing plants have been noticed [1]. The present paper deals with synthesis of new benzothiazolium salts and study of the influence of substituents on benzene ring in benzothiazole at the positions 4 and 6 on

stimulation and inhibitory effects on plant growth as well as on antimicrobial activity [2, 3]. The compounds of the formula




$R^1 = H$

were prepared by the same method as in [2] and are presented in Table 1. By heating 4-chloro- and 4-methylbenzothiazoles with iodomethane and bromomethane in dimethylformamide and acetone (volume ratio 2:1) only 8—10 % yields were obtained (Method *A*). These salts were prepared in sealed tubes (Method *B*) and the yields increased to 42—65 %. Decreased reactivity was observed also in the reaction of 6-chloro- and 6-methylbenzothiazoles with bromomethane. Attempts to prepare 3-substituted benzothiazolium chlorides led to hygroscopic products with yields varying from 5 to 30 %.

The synthesized benzothiazolium salts were active (Table 2) against gram-positive bacteria (*1*, *2*) but essentially less active or not active at all against gram-negative strains (*3*, *4*). Change in substituents (H, $CH_3$, Cl) at the positions 4 and 6 on benzene ring of benzothiazole had not influenced the antimicrobial activity noticeably. These findings were proved and quantitatively expressed by the results of the Free—Wilson analysis carried out after [4]. Also the benzothiazolium salts dealt with in [2] and the compounds with unsubstituted benzyl group in the position 3 have been included into the analysis. Those compounds where some of the substituents appeared in a certain position only once have been excluded from the analysis. Series of 46 compounds of the general formula with two different substituents $R^1$ in the position 2, ten $R^2$ in the position 3, three $R^3$ in the position 4, three $R^3$ in the position 6, and three anions $X^-$ ($X^-$ was taken for a pseudo position) have been considered. There were together 21 substituents in 5 positions. Regarding the condition of symmetry, the system of 46 equations has 29 degrees of freedom [5]. As the magnitude characterizing biological activity, logarithm of the reversed numerical value of molar concentration $c$, corresponding to $ED_{50}$ or $ED_{100}$ values, was chosen. Simultaneously, correlations using directly the $ED_{50}$ and $ED_{100}$ values, expressed in $\mu g/cm^3$, were calculated for better illustration and comparability with minimum inhibitory concentrations. The results of the Free—Wilson analysis are presented in Table 3. The constant $\mu$ represents the mean value of biological activity (activity of the "skeleton") and the $z_{jk}$ values express the contributions of the individual substituents. The multiple correlation coefficients $r$ indicate a relatively good statistical correlation significance. Better significance was achieved when the $ED_{100}$ values were used as the magnitudes characterizing the

*Table 1*

Characterization of the synthesized benzothiazolium salts of the general formula ; $R^1 = H$

| Compound | $R^2$ | $R^3$ | X | Formula | $M_r$ | $w_i$ (calc.)/$w_i$ (found) | | | | Yield % | M.p. °C | Method of preparation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % C | % H | % N | % S | | | |
| *I* | $CH_3$ | 6-$CH_3$ | I | $C_9H_{10}INS$ | 291.16 | 37.13 | 3.46 | 4.81 | 11.01 | 83 | 212—214 | *A* |
| | | | | | | 36.95 | 3.37 | 4.83 | 10.89 | | | |
| *II* | $CH_3$ | 6-$CH_3$ | Br | $C_9H_{10}BrNS$ | 244.16 | 44.27 | 4.13 | 5.74 | 13.13 | 65 | 205—207 | *B* |
| | | | | | | 44.08 | 4.16 | 5.50 | 12.97 | | | |
| *III* | $CH_2CH=CH_2$ | 6-$CH_3$ | Br | $C_{11}H_{12}BrNS$ | 270.20 | 48.90 | 4.48 | 5.18 | 11.87 | 77 | 191—192 | *A* |
| | | | | | | 48.78 | 4.41 | 5.07 | 11.87 | | | |
| *IV* | $CH_2C\equiv CH$ | 6-$CH_3$ | Br | $C_{11}H_{10}BrNS$ | 268.18 | 49.26 | 3.75 | 5.22 | 11.95 | 70 | 215—216 | *A* |
| | | | | | | 49.13 | 3.69 | 5.24 | 11.83 | | | |
| *V* | $CH_2COOCH_3$ | 6-$CH_3$ | Br | $C_{11}H_{12}BrNO_2S$ | 302.19 | 43.70 | 4.00 | 4.63 | 10.61 | 64 | 101—103 | *A* |
| | | | | | | 43.52 | 3.96 | 4.58 | 10.49 | | | |
| *VI* | $CH_2COOC_2H_5$ | 6-$CH_3$ | Br | $C_{12}H_{14}BrNO_2S$ | 316.22 | 45.58 | 4.46 | 4.43 | 10.14 | 67 | 207 | *A* |
| | | | | | | 45.39 | 4.40 | 4.40 | 10.21 | | Decomposition | |
| *VII* | $CH_2COOC_3H_7$ | 6-$CH_3$ | Br | $C_{13}H_{16}BrNO_2S$ | 330.26 | 47.28 | 4.88 | 4.24 | 9.71 | 72 | 204 | *A* |
| | | | | | | 47.42 | 5.01 | 4.32 | 9.87 | | Decomposition | |
| *VIII* | $CH_2COOCH(CH_3)_2$ | 6-$CH_3$ | Br | $C_{13}H_{16}BrNO_2S$ | 330.26 | 47.28 | 4.88 | 4.24 | 9.71 | 78 | 241 | *A* |
| | | | | | | 47.47 | 5.08 | 4.36 | 9.76 | | Decomposition | |
| *IX* | $CH_2COOCH_2CH=CH_2$ | 6-$CH_3$ | Br | $C_{13}H_{14}BrNO_2S$ | 328.24 | 47.57 | 4.30 | 4.27 | 9.77 | 60 | 173 | *A* |
| | | | | | | 47.63 | 4.19 | 4.27 | 9.72 | | Decomposition | |
| *X* | $CH_3$ | 6-Cl | Br | $C_8H_7BrClNS$ | 264.57 | 36.32 | 2.67 | 5.29 | 12.12 | 58 | 295—298 | *B* |
| | | | | | | 37.50 | 2.65 | 5.19 | 12.28 | | | |
| *XI* | $CH_3$ | 6-Cl | I | $C_8H_7ClINS$ | 311.57 | 30.84 | 2.26 | 4.50 | 10.29 | 73 | 299—301 | *A* |
| | | | | | | 31.02 | 2.18 | 4.32 | 10.30 | | | |
| *XII* | $CH_2CH=CH_2$ | 6-Cl | Br | $C_{10}H_9BrClNS$ | 290.61 | 41.33 | 3.12 | 4.82 | 11.03 | 71 | 210—212 | *A* |
| | | | | | | 41.21 | 3.07 | 4.65 | 11.03 | | | |
| *XIII* | $CH_2C\equiv CH$ | 6-Cl | Br | $C_{10}H_7BrClNS$ | 288.60 | 41.62 | 2.44 | 4.85 | 11.11 | 65 | 221 | *A* |
| | | | | | | 41.45 | 2.41 | 4.64 | 11.21 | | Decomposition | |

*Table 1* (Continued)

| Compound | $R^2$ | $R^1$ | X | Formula | $M_r$ | $w_i$ (calc.)/$w_i$ (found) % C | % H | % N | % S | Yield % | M.p. °C | Method of preparation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *XIV* | $CH_2COOCH_3$ | 6-Cl | Br | $C_{10}H_9BrClNO_2S$ | 322.61 | 37.23 | 2.81 | 4.34 | 9.94 | 61 | 170 | *A* |
| | | | | | | 37.42 | 2.85 | 4.23 | 10.05 | | Decomposition | |
| *XV* | $CH_2COOC_2H_5$ | 6-Cl | Br | $C_{11}H_{11}BrClNO_2S$ | 336.64 | 39.25 | 3.29 | 4.16 | 9.52 | 64 | 189 | *A* |
| | | | | | | 39.33 | 3.21 | 3.97 | 9.57 | | Decomposition | |
| *XVI* | $CH_2COOC_3H_7$ | 6-Cl | Br | $C_{12}H_{13}BrClNO_2S$ | 350.67 | 41.10 | 3.74 | 3.99 | 9.14 | 57 | 176 | *A* |
| | | | | | | 41.09 | 3.74 | 3.88 | 9.09 | | Decomposition | |
| *XVII* | $CH_2COOCH(CH_3)_2$ | 6-Cl | Br | $C_{12}H_{13}BrClNO_2S$ | 350.67 | 41.10 | 3.74 | 3.99 | 9.14 | 61 | 230 | *A* |
| | | | | | | 40.85 | 3.93 | 3.91 | 9.12 | | Decomposition | |
| *XVIII* | $CH_2COOCH_2CH=CH_2$ | 6-Cl | Br | $C_{12}H_{11}BrClNO_2S$ | 348.65 | 41.34 | 3.18 | 4.02 | 9.20 | 57 | 157 | *A* |
| | | | | | | 41.12 | 3.18 | 3.86 | 9.12 | | Decomposition | |
| *XIX* | $CH_3$ | 4-$CH_3$ | I | $C_9H_{10}INS$ | 291.16 | 37.13 | 3.46 | 4.81 | 11.01 | 52 | 242 | *B* |
| | | | | | | 37.26 | 3.48 | 4.93 | 11.04 | | Decomposition | |
| *XX* | $CH_3$ | 4-$CH_3$ | Br | $C_9H_{10}BrNS$ | 244.16 | 44.27 | 4.13 | 5.74 | 13.13 | 45 | 209—212 | *B* |
| | | | | | | 44.06 | 4.28 | 5.62 | 12.97 | | | |
| *XXI* | $CH_2CH=CH_2$ | 4-$CH_3$ | Br | $C_{11}H_{12}BrNS$ | 270.20 | 48.90 | 4.48 | 5.18 | 11.87 | 47 | 198—199 | *A* |
| | | | | | | 48.67 | 4.55 | 5.30 | 11.98 | | | |
| *XXII* | $CH_2C\equiv CH$ | 4-$CH_3$ | Br | $C_{11}H_{10}BrNS$ | 268.18 | 49.26 | 3.75 | 5.22 | 11.95 | 43 | 245 | *A* |
| | | | | | | 49.30 | 3.77 | 5.06 | 11.91 | | Decomposition | |
| *XXIII* | $CH_3$ | 4-Cl | I | $C_8H_7ClINS$ | 311.57 | 30.84 | 2.26 | 4.50 | 10.29 | 42 | 261—263 | *B* |
| | | | | | | 30.82 | 2.15 | 4.39 | 10.31 | | | |
| *XXIV* | $CH_3$ | 4-Cl | Br | $C_8H_7ClNS$ | 264.57 | 36.32 | 2.67 | 5.29 | 12.12 | 28 | 253—255 | *B* |
| | | | | | | 36.11 | 2.59 | 5.14 | 12.25 | | | |
| *XXV* | $CH_3$ | 4-Cl | $CH_3SO_4$ | $C_9H_{10}ClNO_4S_2$ | 295.77 | 36.55 | 3.41 | 4.74 | 21.68 | 53 | 145 | *A* |
| | | | | | | 36.65 | 3.39 | 4.61 | 21.74 | | Decomposition | |

*Table 2.* Antimicrobial activity of the synthesized benzothiazolium salts

| Compound | Minimum inhibitory amount $a$/(μg/disc) [10] | | | | Fungicidal/-statical mass concentration $\varrho$/(μg cm$^{-3}$) | | $ED_{100}$ μg cm$^{-3}$ | $ED_{50}$ μg cm$^{-3}$ |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *1* | *1* |
| *I* | 12.5 | 12.5 | 50 | 12.5 | 50/12.5 | 12.5/3.1 | 8.2 | 4.6 |
| *II* | 12.5 | 12.5 | 50 | 50 | 50/12.5 | 50/12.5 | 8.4 | 4.5 |
| *III* | 12.5 | 12.5 | 200 | 50 | 50/12.5 | 12.5/3.1 | 9.3 | 4.9 |
| *IV* | 12.5 | 12.5 | 200 | 50 | 50/12.5 | 12.5/3.1 | 9.2 | 4.9 |
| *V* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 15.0 | 7.5 |
| *VI* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 14.0 | 7.0 |
| *VII* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 13.5 | 6.0 |
| *VIII* | 50 | 50 | 200 | 200 | 200/50 | 200/50 | 17.5 | 8.0 |
| *IX* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 12.0 | 5.8 |
| *X* | 12.5 | 12.5 | 50 | 50 | 50/12.5 | 50/12.5 | 7.5 | 4.0 |
| *XI* | 12.5 | 12.5 | 50 | 50 | 50/3.1 | 12.5/3.1 | 7.2 | 3.9 |
| *XII* | 12.5 | 12.5 | 200 | 50 | 50/12.5 | 50/3.1 | 9.4 | 4.1 |
| *XIII* | 12.5 | 12.5 | 200 | 50 | 50/12.5 | 50/3.1 | 9.3 | 4.1 |
| *XIV* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 12.5 | 6.0 |
| *XV* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 11.5 | 5.8 |
| *XVI* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 11.5 | 6.0 |
| *XVII* | 12.5 | 12.5 | 200 | 200 | 200/200 | 200/50 | 13.0 | 6.5 |
| *XVIII* | 12.5 | 12.5 | 200 | 200 | 200/50 | 50/12.5 | 11.6 | 6.0 |
| *XIX* | 12.5 | 12.5 | 50 | 50 | 50/12.5 | 50/12.5 | 8.2 | 4.1 |
| *XX* | 12.5 | 12.5 | 50 | 50 | 50/12.5 | 50/12.5 | 9.1 | 5.0 |
| *XXI* | 12.5 | 12.5 | 200 | 200 | 50/12.5 | 50/12.5 | 8.3 | 4.0 |
| *XXII* | 12.5 | 12.5 | 200 | 200 | 50/12.5 | 50/12.5 | 8.3 | 4.1 |
| *XXIII* | 12.5 | 12.5 | 50 | 200 | 50/12.5 | 50/12.5 | 7.2 | 3.7 |
| *XXIV* | 12.5 | 12.5 | 200 | 200 | 50/12.5 | 50/12.5 | 8.3 | 4.0 |
| *XXV* | 12.5 | 12.5 | 200 | 200 | 50/12.5 | 50/12.5 | 8.3 | 4.0 |

*1. Staphylococcus aureus ATCC 6538; 2. Bacillus subtilis ATCC 6051; 3. Escherichia coli ATCC 9637; 4. Pseudomonas aeruginosa ATCC 10145; 5. Microsporum gypseum; 6. Trichophyton rubrum.*

*Table 3*

Results of the Free—Wilson analysis

| Position | Substituent | Number of substituents | $ED_{50}/(\mu g\ cm^{-3})$ | | $-\log\{c(ED_{50})\}$ | | $ED_{100}/(\mu g\ cm^{-3})$ | | $-\log\{c(ED_{100})\}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ |
| $R^1$ | H | 42 | −0.919 | 10.565 | 0.040 | 0.462 | −1.612 | 18.541 | 0.036 | 0.414 |
| | $CH_3$ | 4 | 9.646 | | −0.422 | | 16.929 | | −0.378 | |
| $R^2$ | $CH_3$ | 12 | −0.956 | 6.799 | 0.019 | 0.311 | −3.261 | 10.507 | 0.067 | 0.219 |
| | $C_2H_5$ | 2 | −3.900 | | 0.158 | | −4.496 | | 0.064 | |
| | $CH_2CH=CH_2$ | 5 | −2.944 | | 0.131 | | −3.523 | | 0.078 | |
| | $CH_2C\equiv CH$ | 5 | −2.564 | | 0.113 | | −3.223 | | 0.072 | |
| | $CH_2COOCH_3$ | 3 | 2.533 | | −0.153 | | 4.911 | | −0.141 | |
| | $CH_2COOC_2H_5$ | 3 | 2.099 | | −0.110 | | 4.178 | | −0.098 | |
| | $CH_2COOC_3H_7$ | 3 | 1.166 | | −0.044 | | 1.944 | | −0.026 | |
| | $CH_2COOCH(CH_3)_2$ | 3 | 2.899 | | −0.136 | | 6.011 | | −0.132 | |
| | $CH_2COOCH_2CH=CH_2$ | 3 | 0.233 | | 0.010 | | 0.444 | | −0.019 | |
| | $CH_2C_6H_5$ | 7 | 2.861 | | −0.066 | | 4.198 | | −0.078 | |
| 4-$R^3$ | H | 39 | 0.076 | 0.911 | −0.009 | 0.105 | 0.245 | 1.628 | −0.011 | 0.092 |
| | $CH_3$ | 4 | −0.116 | | 0.013 | | −1.383 | | 0.049 | |
| | Cl | 3 | −0.835 | | 0.096 | | −1.344 | | 0.081 | |
| 6-$R^3$ | H | 24 | 0.734 | 2.025 | −0.044 | 0.145 | 1.528 | 4.103 | −0.052 | 0.155 |
| | $CH_3$ | 11 | −0.309 | | −0.005 | | −0.756 | | 0.011 | |
| | Cl | 11 | −1.291 | | 0.101 | | −2.575 | | 0.103 | |

*Table 3* (Continued)

| Position | Substituent | Number of substituents | $ED_{50}/(\mu g\ cm^{-3})$ | | $-\log\{c(ED_{50})\}$ | | $ED_{100}/(\mu g\ cm^{-3})$ | | $-\log\{c(ED_{100})\}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ | $z_{jk}$ | $\Delta z_{jk}$ |
| X | Br | 34 | 0.387 | 1.507 | −0.031 | 0.121 | 0.329 | 1.612 | −0.025 | 0.098 |
| | I | 10 | −1.120 | | 0.090 | | −0.863 | | 0.073 | |
| | $CH_3OSO_3$ | 2 | −0.975 | | 0.073 | | −1.283 | | 0.056 | |
| Constant $\mu$ | | | 6.445 | | 4.717 | | 13.228 | | 4.398 | |
| Multiple correlation coefficient $r$ | | | 0.881 | | 0.937 | | 0.966 | | 0.962 | |
| $F$ value | | | 6.269 | | 13.061 | | 25.166 | | 22.589 | |

$z_{jk}$ — Contribution of the substituent;
$\Delta z_{jk}$ — maximum extent of contributions of substituents in the given position;
$c$ — molar concentration corresponding to the $ED_{50}$ and $ED_{100}$ values, respectively.

biological activity. The significance was approximately the same in both cases, *i.e.* when using the linear scale with the $ED_{100}$ values in $\mu g/cm^3$ or the logarithm scale with molar concentrations $c$. Comparison of the $F$ values with the tabular values for 29 degrees of freedom showed that the correlation significance had been above 99.5 % probability level. The $z_{jk}$ values quantitatively expressed and proved the conclusions about the effect of substituents on biological activity, which has been already mentioned. It is evident from comparison of the $\Delta z_{jk}$ values, representing the difference between maximum and minimum contributions of $z_{jk}$ in the individual positions, that the greatest changes in the followed region of biological activity were brought about by changes of substituents in the positions 2 and 3. The $z_{jk}$ values for the positions 4 and 6 as well as for the anion $X^-$ were essentially lower. The $\mu$ values and the contributions of the substituents $z_{jk}$ enable to calculate the biological activity not only for benzothiazolium salts used in the analysis but also for further compounds not synthesized yet. When using 21 substituents in 5 positions the total number would be $2 \times 10 \times 3 \times 3 \times 3$. The best values calculated were those for the compounds unsubstituted in the position 2, having chlorine atom in the positions 4 and 6, and ethyl or allyl groups in the position 3. However, these values did not exceed very much the best values measured. When considering the possible errors, it is not probable that the new compounds with such combination of substituents would be essentially more active.

It was found that introduction of Cl or $CH_3$ into the positions 4 and 6 of the synthesized benzothiazolium salts resulted in decrease of the stimulation activity. In some cases this property vanished completely and the compounds acted as typical inhibitors. The obtained results are summarized in Table 4. As each benzothiazolium salt has its own characteristic activity curve, those concentrations are presented in the table at which the highest activity was observed. From the practical point of view 6-methyl-3-propoxycarbonylmethylbenzothiazolium bromide (*VII*) was interesting since its stimulation activity was found to be higher than that of $\beta$-indolylacetic acid. 4-Chloro-3-methylbenzothiazolium bromide (*XXIV*) and 4-chloro-4-methylbenzothiazolium methyl sulfate were proved to be good inhibitors with the activity curve from $c = 10^{-13}$—$10^{-3}$ mol $dm^{-3}$ in the inhibition range. Since the synthesized compounds are soluble in water their application is simple.

## Experimental

6-Substituted 2-aminobenzothiazoles, starting compounds for the preparation of 6-substituted benzothiazoles, were prepared by thiocyanation of the appropriate $p$-substituted anilines [6] and similarly, 4-substituted 2-aminobenzothiazoles from $o$-substituted anilines by conversion to thioureas and cyclization by treatment with bromine [7]. 4,6-Substituted

*Table 4*

Stimulation and inhibitory effects of benzothiazolium salts on growth of vetch

| Compound | Stimulation | | Inhibition | |
|---|---|---|---|---|
| | $+\Delta l$/mm | $c$/(mol dm$^{-3}$) | $-\Delta l$/mm | $c$/(mol dm$^{-3}$) |
| *I* | 1.3 | $10^{-13}$ | 6.8 | $10^{-3}$ |
| *II* | 2.55 | $10^{-11}$ | | |
| *III* | | | 10.0 | $10^{-3}$ |
| *IV* | | | 6.7 | $10^{-3}$ |
| *V* | 1.85 | $10^{-5}$ | 10.0 | $10^{-3}$ |
| *VI* | 3.25 | $10^{-7}$ | 5.5 | $10^{-3}$ |
| *VII* | 3.25 | $10^{-13}$ | | |
| *VIII* | | | 7.9 | $10^{-3}$ |
| *IX* | | | 8.6 | $10^{-3}$ |
| *X* | 3.1 | $10^{-7}$ | 4.8 | $10^{-3}$ |
| *XI* | 2.75 | $10^{-11}$ | 13.3 | $10^{-3}$ |
| *XII* | 3.15 | $10^{-7}$ | 13.0 | $10^{-3}$ |
| *XIV* | | | 10.9 | $10^{-3}$ |
| *XV* | | | 9.8 | $10^{-3}$ |
| *XVII* | | | 5.7 | $10^{-3}$ |
| *XVIII* | 2.35 | $10^{-9}$ | | |
| *XIX* | | | 15.0 | $10^{-3}$ |
| *XX* | | | 14.6 | $10^{-3}$ |
| *XXI* | | | 7.4 | $10^{-3}$ |
| *XXII* | | | 6.4 | $10^{-3}$ |
| *XXIV* | | | 19.1 | $10^{-3}$ |
| *XXV* | | | 19.2 | $10^{-3}$ |
| IAA | 3.10 | $10^{-12}$ | 18.5 | $10^{-6}$ |
| 2,4-D | 4.85 | $10^{-9}$ | 23.3 | $10^{-5}$ |

IAA: $\beta$-Indolylacetic acid;
2,4-D: 2,4-dichlorophenoxyacetic acid.

benzothiazoles were prepared by deamination of the corresponding 2-aminobenzothiazoles [8]. Yields, melting points (determined on a Kofler block), and analytical data of the synthesized compounds are presented in Table 1.

Antimicrobial activity was followed on bacterial strains of gram-positive *Staphylococcus aureus ATCC 6538* (*1*) and *Bacillus subtilis ATCC 6051* (*2*) as well as on gram-negative *Escherichia coli ATCC 9637* (*3*) and *Pseudomonas aeruginosa ATCC 10145* (*4*). Antifungal activity was examined by the test-tube dilution method [9] on strains isolated from pathogenic nest of *Microsporum gypseum* (*5*) and *Trichophyton rubrum* (*6*). The activity of benzothiazolium salts on gram-positive (*1, 2*) and gram-negative (*3, 4*) bacterial strains was tested by the plate-disc method [10] at amounts $a$/(μg/disc): 200, 50, 12.5, and 3.1, on pathogenic moulds (*5, 6*) by the test-tube dilution method [9] at mass concentration $\varrho$/(μg/cm$^3$) 200, 50, 12.5, and 3.1. The activity on the bacterial strain (*1*) was established

also on a Spekol-ZV spectrophotometer at 37 °C and $\lambda = 460$ nm and was expressed in $ED_{100}$ and $ED_{50}$ values (μg/cm³). Growth stimulation of roots was established by the method after [11] on a model object of *Vicia sativa*. Stimulation activities of the synthesized compounds are presented in Table 4. The tested benzothiazolium salts were prepared by the method *A* described in [2] or by the method *B*.

### *Benzothiazolium salts II, X, XIX, XX, XXIII, XXIV (method B)*

The solution (0.025 mol) of the substituted benzothiazole in acetone (5 cm³) and the appropriate alkylation agent (0.03 mol) were poured into a glass ampoule. After cooling to $\theta = -60$ to $-80$ °C the ampoule was sealed off and gradually heated to $\theta = 55$—60 °C in a water bath maintaining this temperature for 10 h. After cooling the quaternary salt was sucked, washed with anhydrous acetone, and recrystallized from anhydrous tetrahydrofuran containing 1—2 % of methanol.

## References

1. Sutoris, V., Sekerka, V., Halgaš, J., and Bajči, P., *Czech. Appl.* 2928-82.
2. Sutoris, V., Halgaš, J., Sekerka, V., Foltínová, P., and Gáplovský, A., *Chem. Zvesti 37*, 653 (1983).
3. Halgaš, J., Sutoris, V., Sekerka, V., Foltínová, P., and Solčániová, E., *Chem. Zvesti 37*, 663 (1983).
4. Purcell, W. P., Bass, G. E., and Clayton, J. M., *Strategy of Drug Design*. J. Wiley & Sons, New York, 1973.
5. Free, S. M., Jr. and Wilson, J. W., *J. Med. Chem. 7*, 395 (1964).
6. Brewster, R. Q. and Danis, F. B., *J. Amer. Chem. Soc. 58*, 1364 (1936).
7. Dalgliesh, C. E. and Mann, F. G., *J. Chem. Soc. 1945*, 893.
8. Cadogan, J. I. G. and Molina, G. A., *J. Chem. Soc., Perkin Trans. I, 1973*, 541.
9. Foltínová, P., Sutoris, V., Blöckinger, G., and Ebringer, L., *Folia Microbiol.* (Prague) *23*, 225 (1978).
10. Foltínová, P., Sutoris, V., Blöckinger, G., and Ebringer, L., *Acta Fac. Rerum Natur. Univ. Comenianae (Microbiologia) 4*, 97 (1976).
11. Sutoris, V., Sekerka, V., and Halgaš, J., *Czech. Appl.* 7634-80.

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