

Alois Pískala*, Jiří Gut, Pavel Fiedler, Milena Masojídková, David Šaman and Radek Liboska

Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic, 166 10 Prague 6, The Czech Republic
Received August 10, 1993

Dedicated to the memory of Professor Roland K. Robins

Treatment of 3,5-dimethoxy-1,2,4-triazine (**1a**) with methyl iodide was found to give depending on the reaction time triazinium iodide **2a**, triaziniumolates **4a** and **6a** as well as methoxytriazinones **7a** and **8a**. Thermolysis of **2a** gave triaziniumolates **4a** and **6a**. Reaction of **2a**, **4a** or methoxytriazinone **9a** with methyl iodide in acetonitrile yielded as the sole product **6a**. Reaction of 3-methoxy-5-methylthio-1,2,4-triazine (**1b**) with methyl iodide gave triazinium iodide **2b** and methylthio triazinone **7b**. Hydrolysis of **2a,b** afforded **4a**. Reaction of 5-methoxy-3-methylthio-1,2,4-triazine (**1c**) with methyl iodide gave triazinium iodide **2c**, triaziniumolate **4b**, triazinium iodide **5b** and triazinone **8b**. Hydrolysis of **2c** yielded **4b** and its thermolysis gave a mixture of **4b** and **5b**. Reaction of **2c**, **4b** and triazinone **9b** with methyl iodide afforded **5b**. Treatment of 3,5-bis(methylthio)-1,2,4-triazine (**1d**) with methyl iodide was found to give a mixture of N1 and N2 methiodides **2d** and **3d** which gave on hydrolysis **4b** and **8b**, respectively. Methylation of 6-methyl derivatives **1e-g** gave analogous results, however the proportions of N1 methylated products were lower and the reaction rates higher in comparison to their respective lower homologues **1a,c,d**. The structures of the mesoionic dimethyl derivatives were assigned from uv, ir, ¹H nmr and electron impact mass spectra. The structural assignments were eventually confirmed by quantum chemical calculations of net charge distributions, bond lengths and ipso angles of the C5-O bonds.

J. Heterocyclic Chem., **30**, 1317 (1993).

To our knowledge, the first mesoionic 1,2,4-triaziniumolates have been prepared in our laboratory by reaction of 1,2,4-triazine-3,5(2*H*,4*H*)-dione (6-azauracil) with dimethyl sulfate [1,2] or on treatment of 3,5-dimethoxy-1,2,4-triazine (**1a**) and the related compounds **1b,c** with methyl iodide [3]. Later on, Doleschall and Lempert [4] reported the synthesis of some 1,2,4-triazinoquinazoliumolates. Also Kakehi *et al* [5], Batori *et al* [6,7] and Messmer *et al* [8] succeeded in the preparation of some pyrido-1,2,4-triaziniumolates. Recently Jacobsen and Rose [9-11] prepared new 1-methyl-1,2,4-triaziniumolates by methylation of various 3 and 6-substituted 1,2,4-triazin-5(2*H*)-ones with diazomethane or methyl iodide in the presence of aqueous alkali. The mesoionic 4,5-dihydro-1,4-dimethyl-5-thioxo-1,2,4-triazinium-3-olate [12] was obtained in our laboratory as a minute by-product of the methylation of the respective 4-methyl derivative. In this present paper we wish to give an account of our work on the preparation of mesoionic dimethyl derivatives of some 1,2,4-triazinones and the course of the reaction of triazines **1a-g** with methyl iodide.

In connection with the study of alkylation or glycosylation of 1,2,4-triazine-3,5(2*H*,4*H*)-dione and its congeners we were interested in the applicability of the well known Hilbert-Johnson [13-15] reaction which is commonly

used for the preparation of *N*-alkyl and *N*-glycosyl derivatives of pyrimidinones and similar nitrogen heterocycles. This procedure may be generally formulated as a reaction of 2,4-dialkoxypyrimidines or related heterocyclic compounds with alkyl or glycosyl halides which affords the above mentioned *N*-substituted products. A general scheme was proposed for the Hilbert-Johnson reaction involving quaternization of nitrogen followed by dealkylation of the labile intermediate by halide ion [16].

In contrast to the methylation of 1,2,4-triazine-3,5(2*H*,4*H*)-dione with alkyl halides [17] in the presence of aqueous alkali or with diazomethane [18] which affords depending on reaction conditions and the alkylating agent the 2 and 4-methyl or 2,4-dimethyl derivatives, the Hilbert-Johnson reaction of 3,5-dimethoxy-1,2,4-triazine (**1a**) with methyl iodide should yield predominantly 5-methoxy-2-methyl-1,2,4-triazin-3(2*H*)-one (**7a**). However, the reaction of 3,5,6-trisubstituted alkyl-1,2,4-triazines with methyl iodide affords mixtures of 1 and 2-methyl-1,2,4-triazinium iodides [19]. Recently similar results have been obtained with 5,6-disubstituted alkyl-1,2,4-triazin-3-amines [20]. On the basis of these studies one could assume in the methylation of **1a** also the formation of 1-methyltriazinium salts which should transform into triaziniumolates. In fact, the reaction of **1a** with

methyl iodide afforded depending on reaction time five methylation products. Treatment of **1a** with methyl iodide at room temperature (30 days) furnished 3-methoxy-1-methyl-1,2,4-triazinium-5-olate (**4a**), 4,5-dihydro-1,4-dimethyl-5-oxo-1,2,4-triazinium-3-olate (**6a**), 5-methoxy-2-methyl-1,2,4-triazin-3(2*H*)-one (**7a**) and 3-methoxy-2-methyl-1,2,4-triazin-5(2*H*)-one (**8a**) in 5, 34, 52 and 2% yields, respectively. The triaziniumolate **6a** is formed *via* the unstable but isolable orange colored 3,5-dimethoxy-1-methyl-1,2,4-triazinium iodide (**2a**) which splits off methyl iodide by selective demethylation of the methoxy group in position 5 to give **4a**. The latter compound is then slowly methylated at position 4 to form the unisolable triazinium iodide **5a** which is demethylated to the rather stable triazinium-3-olate **6a**. In like manner the 2-methyl derivatives **7a** and **8a** are formed by demethylation of the methoxy group in position 3 or 5, respectively, of the unisolable triazinium iodide **3a**.

Our earlier study [21] on the preparation of **1a** has shown that this compound is selectively demethylated by sodium methanethiolate at the methoxy group in position 5. Quaternization on N1 does not change the regioselectivity of demethylation. In contrast, quaternization on N2 due to the influence of steric and electrostatic factors [22] activates to a larger extent the methoxy group in position 3 than the methoxy group in position 5.

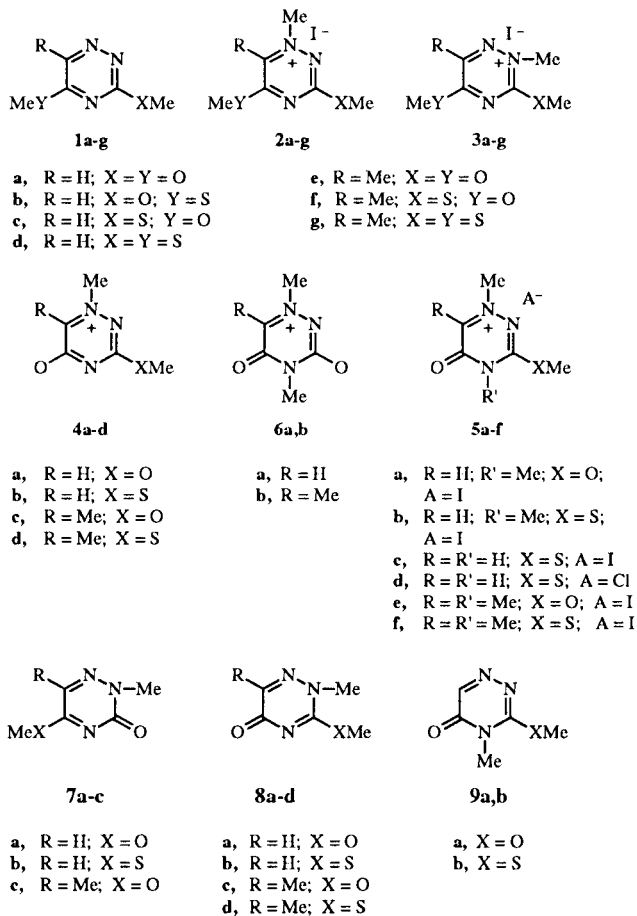
Treatment of **1a** with methyl iodide at room temperature for 20 hours gave in 22% yield triazinium iodide **2a**. Heating of **2a** at 100° *in vacuo* afforded triaziniumolates **4a** and **6a** in 73 and 23% yields, respectively. The same products have been formed on storage of triazinium iodide **2a** for several months.

In order to prove the proposed course of methylation of **1a**, also 3-methoxy-5-methylthio-1,2,4-triazine (**1b**) was reacted with methyl iodide at room temperature (4 days). In this case the rather stable orange colored 3-methoxy-1-methyl-5-methylthio-1,2,4-triazinium iodide (**2b**) and 2-methyl-5-methylthio-1,2,4-triazin-3(2*H*)-one (**7b**) were obtained in 39 and 56% yields, respectively. The triazinone **7b** is obviously formed *via* the unisolable triazinium iodide **3b**.

Mild alkaline hydrolysis of triazinium iodides **2a,b** gave in high yields triazinium-5-olate **4a**. The reaction of **4a** or triazinium iodide **2a** with methyl iodide in acetonitrile at reflux temperature (4 hours) afforded triazinium-3-olate **6a** in high yields. The same product was also obtained in a 95% yield on methylation of 3-methoxy-4-methyl-1,2,4-triazin-5(4*H*)-one (**9a**) with methyl iodide at room temperature (10 days). The transformation of **2a**, **4a** and **9a** to triaziniumolate **6a** proceeds undoubtedly *via* the unisolable triazinium iodide **5a**. The presence of **5a** in the reaction mixture is evidenced by the formation of a red color which disappears when the reaction is completed.

In connection with this study it was also of interest to know the course of methylation of the positional isomer of **1b**, namely 5-methoxy-3-methylthio-1,2,4-triazine (**1c**). Treatment of the latter compound with methyl iodide at room temperature for 22 hours gave in 32% yield the orange colored 5-methoxy-1-methyl-3-methylthio-1,2,4-triazinium iodide (**2c**). When the reaction mixture was kept for an additional 8 days at room temperature, 4,5-dihydro-1,4-dimethyl-3-methylthio-5-oxo-1,2,4-triazinium iodide (**5b**), 1-methyl-3-methylthio-1,2,4-triazinium-5-olate (**4b**) and 2-methyl-3-methylthio-1,2,4-triazin-5(2*H*)-one (**8b**) were obtained in 22, 4 and 38% yields, respectively. The triazinium iodide **5b** is obviously formed by demethylation of the labile primary product **2c** to triazinium-5-olate **4b** which is subsequently methylated at position 4 to give **5b**. The methylthiotriazinone **8b** is formed by an analogous demethylation of the unisolable triazinium iodide **3c**.

The triazinium-5-olate **4b** was also obtained in a high yield by mild alkaline hydrolysis of triazinium iodide **2c**. Heating of **2c** at 100° *in vacuo* afforded triazinium-5-olate **4b** and its methylation product **5b** in 51 and 30% yields, respectively. The products **4b** and **5b** are also formed on storage of the unstable triazinium iodide **2c** for several months. In this connection it should be mentioned



that the triazinium-5-olate **4b** was also prepared by Jacobsen and Rose [9] on methylation of 3-methylthio-1,2,4-triazin-5(2*H*)-one with diazomethane or methyl iodide in presence of aqueous alkali.

The triazinium iodide **5b** was moreover obtained in high yields by methylation of **2c** or **4b** with methyl iodide in acetonitrile at reflux temperature. Also the reaction of 4-methyl-3-methylthio-1,2,4-triazin-5(4*H*)-one (**9b**) with methyl iodide at room temperature gave a 99% yield of **5b**.

Hydrolysis of **2c** in the absence of base gave the orange colored 4,5-dihydro-1-methyl-3-methylthio-5-oxo-1,2,4-triazinone iodide (**5c**). By contrast, the analogous chloride **5d** is a colorless compound. A similar situation has been observed by Doleschall and Lempert [4] in the case of analogous condensed 1,2,4-triazinone salts. In our opinion the color of 1-methyltriazinone iodides may be due to the ability of these salts to form complexes with elemental iodine which is always present in minute amounts in the reaction mixtures.

To complete this study also 3,5-bis(methylthio)-1,2,4-triazine (**1d**) was reacted with methyl iodide at room temperature. In this case a 1:1 mixture of the rather stable N1 and N2 methiodides **2d** and **3d** was obtained. Due to difficulties with the separation of the individual isomers the crude mixture of **2d** and **3d** was directly hydrolyzed to give triazinium-5-olate **4b** and triazinone **8b** in 36 and 37% yields, respectively. In order to elucidate the influence of steric factors, the 6-methyl derivatives **1e-g** were also included in this study. The reaction of these compounds with methyl iodide proceeds by analogy to the methylation of the respective lower homologues **1a,c,d**. However, the ratio of N1/N2 methyl derivatives is changed in favour of N2 methyl derivatives and the methylations required shorter reaction times as compared with corresponding triazines **1a,c,d**.

The structures of methoxytriazinones **7a** and **8a** as well as methylthio-triazinones **7b** and **8b,d** were established by direct comparison of these products with compounds previously reported in the literature. The structures of new methoxytriazinones **7c** and **8c** were assigned by a comparison of their uv and ir spectra with the respective data of the lower homologues **7a** and **8a**. The structure proofs of compounds **2** and **4-6** rest on the above described structure proving preparations and the assignments are confirmed by spectral methods. The polar character of triazinone salts **4** and **6** is confirmed by bathochromic shifts of the long-wave maxima in uv spectra (Table 1) and by shifts of the carbonyl bands in ir spectra (Table 2) to lower frequencies, when compared with the corresponding data of the methyl derivatives of 1,2,4-triazin-3,5(2*H*,4*H*)-dione [2,24,26], 3-methoxy [22] and 3-methylthio-1,2,4-triazin-5-one [23,25]. However, com-

Table 1
Ultraviolet spectra of 1,2,4-Triazines **1,2** and **4-8**

| Compound | Solvent or pH | λ max, nm (log ϵ_{\max}) |
|-----------|---------------|--------------------------------------------|
| 1a | EtOH | 212 (3.82), 274 (3.81) |
| 1b | EtOH | 232 (3.78), 251 (3.59), 309 (4.06) |
| 1c | 7.0 | 233 (3.90), 241 (4.01), 296 (3.45) |
| 1e | EtOH | 212 (3.80), 275 (3.68) |
| 1f | EtOH | 248 (4.15), 302 (3.56) |
| 2a | EtOH | 219 (3.69), 288 (3.69) |
| 2b | EtOH | 217 (4.24), 247 (3.94), 341 (3.84) |
| 2c | EtOH | 220 (4.00), 258 (3.99), 319 (3.39) |
| 4a | EtOH | 215 (4.00), 303 (3.75) |
| 4b | EtOH | 233 (4.26), 321 (3.74) |
| 5b | 2.4 | 226 (4.25), 327 (3.83) |
| | 6.9 | 222 (4.35), 275 (3.71) |
| | 11.0 | 222 (4.35), 279 (3.67) |
| 5c | MeOH | 226 (4.43), 320 (3.68) |
| 5d | EtOH | 233 (4.21), 322 (3.68) |
| 5f | EtOH | 221 (4.36), 293 (3.76), 318 (3.75) |
| 6a | EtOH | 319 (3.78) |
| 6b | MeOH | 321 (3.82) |
| 7c | MeOH | 288 (3.80) |
| 8c | EtOH | 228 (4.00), 261 (3.92) |

Table 2
Infrared Spectra of 1,2,4-Triazines **1,2** and **4-8**

| Compound | Medium | ν (C=O), | ν (ring), | cm^{-1} |
|-----------|-------------------|----------------------------|---------------|------------------|
| 1a | chloroform | 1568 vs 1453 s | 1554 vs | 1483 s |
| 1b | chloroform | 1530 s, 1469 m | 1515 vs, | 1505 s, sh |
| 1c | chloroform | 1552 vs | 1540 vs | 1531 s |
| 1e | chloroform | 1581 s 1459 s | 1546 s | 1482 s |
| 1f | chloroform | 1564 s | 1523 s | 1467 s |
| 2a | nujol | 1608 m | 1582 m | 1523 m |
| 2b | nujol | 1590 m | 1535 s | 1483 s |
| 2c | nujol | 1592 s | 1553 s | 1494 s |
| 4a | nujol | 1686 m 1585 s | 1650 s | 1630 vs |
| 4b | nujol | 1658 m 1574 w | 1651 m | 1616 m |
| 5b | nujol | 1710 vs 1493 vs | 1672 w, sh | 1602 m |
| 5d | nujol | 1708 s 1513 s | 1675 m | 1611 m |
| 5f | nujol | 1712 s 1530 s | 1675 w | 1605 m |
| 6a | nujol | 1696 s | 1639 vs,br | 1523 m |
| 6b | potassium bromide | 1692 s 1634 s, vbr | 1642 s, vbr | |
| 7c | chloroform | 1670 vs, br | 1615 vs | 1547 s |
| 8c | chloroform | 1660 vs, br 1535 vs, br | 1602 s | |

parison of the ir spectra of methoxytriazines **1** and triazinone salts **2** with the respective data of triazinone-

Table 3

¹H NMR Spectra of 1,2,4-Triazines **1-8** [28] in DMSO-d₆

| Compound | 6 (ppm), J (Hz) |
|-----------|---------------------------------------------------------------------------------------------------------|
| 1a | 4.03 (3-OMe), 3.96 (5-OMe), 8.78 (6-H) |
| 1b | 4.03 (3-OMe), 2.56 (5-SMe), 9.06 (6-H) |
| 1c | 2.59 (3-SMe), 3.98 (5-OMe), 8.79 (6-H) |
| 1d | 2.59 (3-SMe), 2.57 (5-SMe), 9.08 (6-H) |
| 1e | 3.99 (3-OMe), 3.97 (5-OMe), 2.38 (6-Me) |
| 1f | 2.57 (3-SMe), 3.98 (5-OMe), 2.40 (6-Me) |
| 1g | 2.58 (3-SMe), 2.56 (5-SMe), 2.43 (6-Me) |
| 2a | 4.33 d (1-NMe, ⁴ J = 0.9), 4.13 (3-OMe), 4.21 (5-OMe), 9.74 q (6-H, ⁴ J = 0.9) |
| 2b | 4.27 (1-NMe), 4.14 (3-OMe), 2.77 (5-SMe) 9.93 (6-H) |
| 2c | 4.31 (1-NMe), 2.66 (3-SMe), 4.20 (5-OMe) 9.72 (6-H) |
| 2d | 4.25 (1-NMe), 2.67 (3-SMe), 2.77 (5-SMe) 9.88 (6-H) |
| 2e | 4.30 (1-NMe), 4.09 (3-OMe), 4.19 (5-OMe) 2.70 (6-Me) |
| 2f | 4.31 (1-NMe), 2.65 (3-SMe), 4.19 (5-OMe) 2.70 (6-Me) |
| 2g | 4.29 (1-NMe), 2.67 (3-SMe), 2.74 (5-SMe) 2.53 (6-Me) |
| 3d | 4.07 (2-NMe), 2.83 (3-SMe), 2.87 (5-SMe) 9.30 (6-H) |
| 3g | 4.08 (2-NMe), 2.85 (3-SMe), 2.88 (5-SMe), 2.49 (6-Me) |
| 4a | 3.99 d (1-NMe, ⁴ J = 0.8), 3.78 (3-OMe), 8.21 q (6-H, ⁴ J = 0.8) |
| 4b | 3.98 (1-NMe), 2.39 (3-SMe), 8.20 (6-H) |
| 4c | 3.97 (1-NMe), 3.76 (3-OMe), 2.40 (6-Me) |
| 4d | 3.96 (1-NMe), 2.40 (3-SMe), 2.37 (6-Me) |
| 5b | 4.12 d (1-NMe, ⁴ J = 1.0), 2.69 (3-SMe), 3.44 (4-NMe), 9.36 q (6-H, ⁴ J = 1.0) |
| 5f | 4.15 (1-NMe), 2.67 (3-SMe), 3.47 (4-NMe), 2.65 (6-Me) |
| 6a | 3.92 (1-NMe), 3.14 (4-NMe), 8.14 (6-H) |
| 6b | 3.91 (1-NMe), 3.16 (4-NMe), 2.34 (6-Me) |
| 7c | 3.53 (2-NMe), 3.90 (5-OMe), 2.14 (6-Me) |
| 8c | 3.56 (2-NMe), 3.91 (3-OMe), 2.09 (6-Me) |

Table 4

Lengths (pm) of Selected Bonds of 1, 2, 4-Triazines **2** and **4-6**

| Bond | 2a, c, e, f | 5a, e | 4a-d | 6a, b |
|---------|--------------------|--------------|-------------|--------------|
| N1 - N2 | 131-133 | 135-136 | 132-133 | 130-131 |
| N2 - C3 | 137-139 | 136-137 | 140-141 | 143-144 |
| C3 - N4 | 137-138 | 139 | 132-133 | 145-148 |
| N4 - C5 | 135-136 | 146-147 | 142-143 | 143 |
| C5 - C6 | 143-145 | 148-149 | 148-150 | 147-148 |
| C6 - N1 | 135-136 | 132-133 | 133-135 | 134-135 |
| N1 - Me | 148-149 | 148-149 | 148-149 | 148-149 |
| C5 - O | 133-134 | 121 | 121-122 | 122 |
| C3 - O | 132 | 133 | 135 | 121 |
| C3 - S | 173 | - | 178 | - |

lates **4** indicates that the latter compounds are not truly aromatic and that the negative charge on the exocyclic

Table 5

Ipsos Angles (degree) of the C5 - O Bonds of 1, 2, 4-Triazines **2** and **4-6**

| Compound | 2a, c, e, f | 5a, e | 4a-d | 6a, b |
|----------|--------------------|--------------|-------------|--------------|
| Angle | 116-117 | 116 | 121 | 116 |

Table 6

Charges [a] of Selected Atoms of 1, 2, 4-Triazines **2** and **4-6**

| Atom | 2a, c, e, f | 5a, e | 4a-d | 6a, b |
|------|--------------------|--------------|-------------|--------------|
| O5 | -(34-137) | -(201-217) | -(314-317) | -(350-352) |
| N1 | +(644-718) | +(668-721) | +(702-728) | +(774-793) |
| N2 | -(278-368) | -(429-441) | -(441-513) | -(504-506) |
| N4 | -(103-191) | +80-(-74) | -(253-268) | -(65-66) |
| C5 | +(218-233) | +(276-277) | +(340-345) | +(328-329) |
| C6 | -(286-427) | -(278-355) | -(428-508) | -(508-567) |

[a] In per milles of a charge unit.

oxygen is largely delocalized to the triazine ring. A similar conclusion follows from comparison of the ¹H nmr spectra (Table 3) of triazines **1a-d**, triazinium iodides **2a-c** and triazinium olates **4a,b**. The chemical shift values of the signals of the protons in position 6 of the latter compounds are much smaller than the respective values of the truly aromatic triazines **1a-d** and **2a-c**. The remarkable down field shifts of the resonance signals of the protons in position 6 of triaziniumolates **4a,b** and **6a**, when compared with the corresponding data of 1,2,4-triazinones [22], can be explained by the deshielding effect of the quaternary nitrogen atom in position 1. The structure of triaziniumolates **4a,b** and **6a,b** was also elucidated by quantum chemical calculation of the lengths of selected bonds (Table 4), the ipso angles of the C5-O bonds (Table 5) and the net charges of selected atoms (Table 6) of these compounds. For comparison also the respective parameters of triazinium salts **2a,c,e,f** and **5a,e** were calculated. These results allow to conclude that the C5-O bonds in triaziniumolates **4a-d** and **6a,b** as well as the C3-O bonds in **6a,b** possess double bond character and that the positive charge is localized predominantly at N1. The calculation indicates also planar arrangement of the triazine ring in compounds **4a-d** and **6a,b**. The structure proofs of triaziniumolates **4a-d** and **6a,b** also rest upon electron impact mass spectral data (Table 7) which confirm correct molecular weights and the 1,2,4-triazine character of these compounds. In contrast to triazines **1a-g**, **4a-d** and **6a,b** which exhibited molecular ions in their mass spectra, triazinium iodides **2a-c,e,f** and **5b,f** decomposed on electron bombardment to fragment ions formed by loss of methyl iodide, hydrogen iodide or iodine.

Comparison of the ¹H nmr and the ir spectra of the 1,4-dimethyl derivative **6a** with the respective data for the previously reported analogous 1-methyl derivative [2]

Table 7
Mass Spectra of 1, 2, 4-Triazines **1**, **2** and **4-8**

| Compound | m/z (relative intensity, %) |
|-----------|------------------------------------------------------------------------------------------------------------------------------------|
| 1a | 141 (M ⁺ , 100), 126 (48), 111 (29), 98 (18), 83 (32), 70 (49), 56 (75), 42 (15), 28 (16) |
| 1b | 157 (M ⁺ , 100), 127 (7), 100 (3), 86 (21), 72 (91), 57 (11), 45 (18) 28 (10) |
| 1c | 157 (M ⁺ , 100), 142 (28), 114 (28), 99 (15), 86 (11), 69 (9), 56 (35), 45 (10), 28 (8) |
| 1d | 173 (M ⁺ , 95), 149 (2), 115 (6), 98 (3), 83 (6), 72 (100), 57 (11), 45 (21), 28 (2) |
| 1e | 155 (M ⁺ , 100), 140 (12), 125 (18), 110 (2), 97 (2) 84 (32), 70 (55), 55 (57), 42 (15), 28 (8) |
| 1f | 171 (M ⁺ , 100), 156 (11), 86 (5), 70 (68), 55 (42) 45 (8), 28 (9) |
| 1g | 187 (M ⁺ , 100), 172 (5), 112 (5), 86 (82), 71 (50), 45 (18), 28 (12) |
| 2a | 142 (100), 141 (M ⁺ - MeI, 19), 127 (21), 42 (20), 28 (1) |
| 2b | 157 (M ⁺ - MeI, 9), 142 (100), 127 (12), 110 (9), 86 (12), 42 (2), 28 (1) |
| 2c | 171 (2), 157 (M ⁺ - MeI, 18), 142 (100), 127 (39), 116 (12), 97 (7), 69 (12), 57 (15) 42 (62), 28 (1) |
| 2e | 169 (6), 155 (M ⁺ - MeI, 71), 142 (100), 127 (40), 113 (1), 99 (1), 85 (2), 70 (4), 56 (83), 43 (14), 28 (5) |
| 2f | 185 (33), 171 (M ⁺ - MeI, 98), 143 (8), 142 (8), 128 (22), 127 (15), 110 (9), 88 (7), 74 (8), 56 (100), 42 (8), 28 (10) |
| 4a | 141 (M ⁺ , 69), 129 (1), 112 (18) 100 (12), 83 (8), 69 (9), 57 (11), 42 (100), 28 (9) |
| 4b | 157 (M ⁺ , 62), 124 (5), 116 (32), 96 (6), 84 (10), 69 (9), 57 (11), 42 (100) 28 (3) |
| 4c | 155 (M ⁺ , 35), 140 (2), 127 (8), 70 (8), 56 (100), 43 (15), 42 (3), 28 (12) |
| 4d | 171 (M ⁺ , 45), 156 (2), 143 (2), 110 (11), 98 (8), 84 (5) 74 (10), 56 (100), 43 (41), 42 (25), 28 (22) |
| 5b | 172 (100), 157 (M ⁺ - MeI, 6), 128 (19), 127 (12), 103 (21), 88 (9), 69 (7), 57 (12), 42 (58), 28 (7) |
| 5f | 312 (2), 185 (M ⁺ - HI, 100), 128 (50), 102 (12), 88 (21), 69 (22), 55 (33), 43 (12), 42 (8), 28 (7) |
| 6a | 141 (M ⁺ , 81), 129 (5), 112 (5), 98 (8), 83 (8), 69 (19), 57 (18), 43 (32), 42 (100), 28 (21) |
| 6b | 155 (M ⁺ , 76), 141 (1), 126 (5), 113 (11), 97 (6), 83 (7), 69 (11), 56 (100), 43 (23), 42 (20), 28 (20) |
| 7c | 155 (M ⁺ , 100), 140 (48), 127 (10), 112 (9), 97 (8), 84 (32), 70 (29), 55 (71), 43 (28), 42 (10), 28 (18) |
| 8c | 155 (M ⁺ , 38), 114 (88), 99 (50), 84 (48), 70 (30), 56 (100), 42 (12) 28 (10) |

indicates that the latter compound exists in the 4,5-dihydro tautomeric form and not also in the 2,5-dihydro form as was suggested by the past workers.

The results presented in this paper allow us to conclude that the reaction of 1,2,4-triazines **1a-g** with methyl iodide proceeds primarily at nitrogen atoms in positions 1 and 2 of the triazine ring. The 1-methyltriazinium salts are demethylated or hydrolyzed exclusively at position 5. In contrast, 2-methyltriazinium salts are preferentially demethylated at position 3, but hydrolysis occurs selectively at position 5. Only methoxy groups are demethylated, methylthio groups resist demethylation by the

iodide ion. The ratio of methylation on N1 and N2 depends largely on steric and electronic effects of the substituents in positions 3 and 6. The methylthio group in position 3 lowers as compared with the methoxy group the proportion of N2-methyl derivatives in favour of N1-methyl derivatives. The methyl group in position 6 lowers due to steric hindrance the proportion of N1-methyl derivatives in favour of N2-methyl derivatives. Also the exclusive N4 methylation of triazinium-5-olates **4a-d** as well as the highly selective N1 methylation of triazinones **9a,b** can be explained by the influence of steric factors. The reactivity of triazines **1a-g** towards methyl iodide is influenced predominantly by electronic effects of substituents in positions 3 and 6 and to a lower extent also in position 5. The ease of methylation of triazines **1a-d** decreases in the following order: **1a** > **1b** > **1c** > **1d**. 6-Methyl derivatives **1e-g** are due to the +I effect of the methyl groups which are much more reactive than their lower homologues **1a,c,d**.

EXPERIMENTAL

Triazines **1a,c,g** were prepared by previously reported procedures [21]. Triazine **1b** was obtained as a by-product of methylation of 5-methylthio-1,2,4-triazin-3-one with diazomethane [27]. Unless stated otherwise, the solvents were evaporated at 35°/2.5 KPa and analytical samples were dried at 40 Pa (room temperature). The melting points were determined on a Kofler block and are uncorrected. Thin-layer chromatography (tlc) was performed on Silufol sheets UV 254 (Kavalier, Votice, Czechoslovakia) in ethyl acetate (S1) or 8:2 ethyl acetate:methanol (S2). Spots were detected with uv light at 254 nm. Column chromatography was carried out on silica gel (Separon SGX 40 µm, TESSEK, Czechoslovakia) The uv spectra were taken on a Pye Unicam 8000 spectrophotometer (Cambridge, U.K.) and mass spectra (m/z) on a ZAB-EQ (VG Analytical Ltd., Manchester, U.K.) spectrometer using the EI (electron energy 70 eV) technique. The ¹H nmr spectra were obtained with a Varian UNITY 500 instrument (499.8 MHz) in hexadeuteriodimethyl sulfoxide and the chemical shifts are related to the signal of the solvent (δ DMSO = 2.50 ppm). Chemical shifts (δ) are given in ppm and coupling constants (J) in Hz. The ir spectra were recorded on a Zeiss UR-20 instrument, the wavenumbers are given in cm⁻¹. The quantum chemical calculations were carried out using the program MOPAC, version 6.00 by the method PM3 on the work station RISC 6000/IBM.

Reaction of 3,5-Dimethoxy-1,2,4-triazine (**1a**) with Methyl Iodide.

A solution of **1a** (0.282 g, 2 mmol) in methyl iodide (4 ml) was kept for 30 days at room temperature in a dark place. The originally red color of the mixture disappeared during that time. The precipitate of triaziniumolates **4a** and **6a** was collected and separated on a silica gel column (20 g), prepacked in ethyl acetate. Elution of the column with ethyl acetate:methanol (8:2, v/v) gave 0.095 g (34%) of **6a**, mp 219-221° dec (ethanol), Rf 0.19 (S2) and 0.015 g (5%) of **4a**, mp 187-189° dec (ethanol), Rf 0.12 (S2). The mother liquors remaining after isolation of the

mixture of **4a** and **6a** were evaporated and the residue separated on a silica gel column (15 g), prepacked in ethyl acetate. Elution of the column with ethyl acetate gave 0.147 g (52%) of **7a**, mp 68-69° (benzene-petroleum ether) (lit [22] 67-68°), Rf 0.52 (S1) and 0.006 g (2%) of **8a**, mp 117-118° (benzene-petroleum ether) (lit [22] 118-119°), Rf 0.10 (S1).

3,5-Dimethoxy-1-methyl-1,2,4-triazinium Iodide (**2a**).

A solution of **1a** (1.41 g, 10 mmoles) in methyl iodide (20 ml) was kept for 20 hours at room temperature in a dark place. The orange crystals were collected and air-dried to give 0.630 g (22%) of **2a**, mp 162-177° dec (whitening at ca 100°).

Anal. Calcd. for C₆H₁₀IN₃O₂ (283.1): C, 25.45; H, 3.56; I, 44.83; N, 14.85. Found: C, 25.32; H, 3.41; I, 44.91; N, 14.68.

On allowing the mother liquors to stand for a further 48 hours a second crop of **2a** (0.310 g, 11%), contaminated with minor amounts of **4a** and **6a**, was obtained. Working up of the last mother liquors as described in the preceding experiment gave triazinones **7a** and **8a** in 52 and 2% yields, respectively.

Thermolysis of **2a** (0.283 g, 1 mmole) at 100° for 20 minutes *in vacuo* (water pump pressure) yielded 0.141 g (100%) of a colorless mixture of **4a** and **6a**, mp 154-174° dec. The mixture was separated on a silica gel column (30 g), prepacked in ethyl acetate. Elution of the column with ethyl acetate:methanol (8:2, v/v) afforded 0.103 g (73%) of **4a**, mp 187-189° dec(ethanol) and 0.032 g (23%) of **6a**, mp 219-221° dec (ethanol).

Reaction of 3-Methoxy-5-methylthio-1,2,4-triazine (**1b**) with Methyl Iodide.

A solution of **1b** (0.472 g, 3 mmoles) in methyl iodide (8 ml) was kept for 4 days at room temperature in a dark place. The orange precipitate was collected and air-dried to give 0.350 g (39%) of **2b**, mp 130-132° dec.

Anal. Calcd. for C₆H₁₀IN₃OS (299.1): C, 24.09; H, 3.37; I, 42.44; N, 14.05. Found: C, 24.37; H, 3.49; I, 42.79; N, 14.30.

The mother liquors remaining after isolation of **2b** were evaporated. A solution of the residue in benzene was filtered with charcoal and again evaporated. Crystallization of the residue from benzene-petroleum ether yielded 0.240 g (51%) of **7b**, mp 109-110° (lit [18] 102-104°), Rf 0.60 (S1).

3-Methoxy-1-methyl-1,2,4-triazinium-5-olate (**4a**).

A solution of **2b** (0.299 g, 1 mmole) in water (5 ml) was applied to a Dowex 1 bicarbonate column (10 ml), prepacked in water. Elution of the column with water (50 ml) yielded 0.116 g (82%) of **4a** mp 187-189° dec (ethanol).

Anal. Calcd. for C₅H₇N₃O₂ (141.1): C, 42.55; H, 5.00; N, 29.78. Found: C, 42.82; H, 5.29; N, 30.02.

When **2a** was used as starting compound a 79% yield of **4a** was obtained by the same procedure.

4,5-Dihydro-1,4-dimethyl-5-oxo-1,2,4-triazinium-3-olate (**6a**).

A) A solution of **4a** (0.141 g, 1 mmole) in acetonitrile (5 ml) and methyl iodide (2 ml) was refluxed for 4 hours. Evaporation and recrystallization of the residue from ethanol gave 0.120 g (85%) of **6a**, mp 219-221° dec.

Anal. Calcd. for C₅H₇N₃O₂ (141.1): C, 42.55; H, 5.00; N, 29.78. Found: C, 42.73; H, 4.96; N, 30.06.

When **2a** was used as starting compound a 82% yield of **6a** was obtained by the same procedure.

B) A solution of **9a** (0.282 g, 2 mmoles) in methyl iodide (4 ml) was kept for 10 days at room temperature in a dark place.

The solution became red within 5 minutes after dissolution of the starting compound. The red color disappeared at the end of the reaction. The colorless precipitate was collected to give 0.267 g (95%) of **6a**, mp 219-221° dec (ethanol).

Reaction of 5-Methoxy-3-methylthio-1,2,4-triazine (**1c**) with Methyl Iodide.

A solution of **1c** (1.57 g, 10 mmoles) in methyl iodide (30 ml) was kept for 22 hours at room temperature in a dark place. The orange crystals were collected and air-dried to give 0.95 g (32%) of **2c**, mp 106-108° dec (at rapid heating), upon slow heating the product decolorized at 100-110° and melted at 153-175° dec.

Anal. Calcd. for C₆H₁₀IN₃OS (299.1): C, 24.09; H, 3.37; I, 42.44; N, 14.05. Found: C, 24.35; H, 3.35; I, 42.56; N, 14.14.

The mother liquors remaining after isolation of **2c** were kept for 8 days at room temperature in a dark place. The orange precipitate was collected, washed with hot chloroform and recrystallized from ethanol to afford 0.65 g (22%) of **5b**, mp 190-192° dec.

Anal. Calcd. for C₆H₁₀IN₃OS (299.1): C, 24.09; H, 3.37; I, 42.44; N, 14.05. Found: C, 24.31; H, 3.45; I, 42.72; N, 14.26.

The mother liquors remaining after isolation of **5b** were evaporated and the residue separated on a silica gel column (20 g), prepacked in ethyl acetate. Elution of the column with 100 ml of ethyl acetate and 300 ml of ethyl acetate:methanol (8:2, v/v) gave 0.605 g (38%) of **8b**, mp 164-165° (ethyl acetate) (lit [17] 156-159°), Rf 0.31 (S1) and 0.065 g (4%) of **4b**, mp 191-193° dec (ethanol), Rf 0.35 (S2).

Anal. Calcd. for C₅H₇N₃OS (157.2): C, 38.20; H, 4.49; N, 26.74; S, 20.40. Found: C, 37.94; H, 4.53; N, 26.73; S, 20.61.

1-Methyl-3-methylthio-1,2,4-triazinium-5-olate (**4b**).

A) A solution of **2c** (0.299 g, 1 mmole) in water (5 ml) was applied on a Dowex 1 bicarbonate column (10 ml), prepacked in water. Elution of the column with water (50 ml), evaporation of the eluate and recrystallization of the residue from ethanol afforded 0.122 g (78%) of **4b**, mp 191-193° dec (lit [9] 191-193°).

B) Triazininium iodide **2c** (0.598 g, 2 mmoles) was heated for 45 minutes at 100° (oil bath temperature) *in vacuo* (water pump pressure). The residue was triturated with hot chloroform, the insoluble portion collected and recrystallized from ethanol to give 0.174 g (30%) of **5b**, mp 190-192° dec. The chloroform extract was evaporated and the residue purified on a silica gel column (10 g), prepacked in ethyl acetate. Elution of the column with ethyl acetate:methanol (8:2, v/v) gave 0.160 g (51%) of **4b**, mp 192-193° dec(ethanol).

4,5-Dihydro-1,4-dimethyl-3-methylthio-5-oxo-1,2,4-triazinium Iodide (**5b**).

A) A mixture of **2c** (0.299 g, 1 mmole), acetonitrile (5 ml) and methyl iodide (1 ml) was refluxed for 4 hours. Evaporation of the solvents and crystallization of the residue from ethanol yielded 0.194 g (65%) of **5b**, mp 190-192° dec.

When **4b** was used as the starting compound a 72% yield of **5b** was obtained by the same procedure.

B) A solution of **9b** (0.157 g, 1 mmole) in methyl iodide (10 ml) was kept for 8 days at room temperature in a dark place. The orange crystals were collected and air-dried to yield 0.295 g (99%) of **5b**, mp 186-189° dec.

4,5-Dihydro-1-methyl-3-methylthio-5-oxo-1,2,4-triazinium Iodide (**5c**).

A solution of **2c** (0.299 g, 1 mmole) in a mixture of ethanol (5 ml) and water (1 ml) was refluxed for 5 minutes and evaporated. The residue was triturated with hot ethanol (3 ml) and the mixture kept overnight in a refrigerator. The orange crystals were collected and air-dried to give 0.190 g (67%) of **5c**, mp 202-203° dec.

Anal. Calcd. for $C_5H_8IN_3OS$ (285.1): C, 21.06; H, 2.83; I, 44.51; N, 14.74. Found: C, 21.32; H, 2.78; I, 44.47; N, 14.91

4,5-Dihydro-1-methyl-3-methylthio-5-oxo-1,2,4-triazinium Chloride (**5d**).

A mixture of **4b** (0.157 g, 1 mmole) and methanol (2 ml) was treated with a 4 M solution of dry hydrogen chloride in ether (1 ml) and the mixture evaporated. Trituration of the residue with ethanol (1 ml) gave 0.125 g (65%) of **5d** as white crystals, mp 178-180° dec.

Anal. Calcd. for $C_5H_8ClN_3OS$ (193.7): C, 31.00; H, 4.17; Cl, 18.31; N, 21.69. Found: C, 31.25; H, 4.05; Cl, 18.24; N, 21.94.

Reaction of 3,5-Bis(methylthio)-1,2,4-triazine (**1d**) with Methyl Iodide.

A solution of **1d** (3.46 g, 20 mmoles) in methyl iodide (40 ml) was kept for 9 days at room temperature in a dark place. The red crystals were collected and air-dried to give 6.20 g (99%) of a 1:1 mixture (estimated by 1H nmr spectra) of **2d** and **3d**, mp 155-168° dec.

Anal. Calcd. for $C_6H_{10}IN_3S_2$ (315.2): C, 22.86; H 3.19; I, 40.26; N, 13.33. Found: C, 23.15; H, 3.25; I, 40.54; N, 13.27.

Hydrolysis of the Mixture of Isomeric Methyl-3,5-bis-(methylthio)-1,2,4-triazinium Iodides **2d** and **3d**.

A solution of the mixture of **2d** and **3d** (0.634 g, 2 mmoles) in a 1:1 mixture of methanol and water (40 ml) was applied on a Dowex 1 bicarbonate column (20 ml), prepacked in water. The column was eluted with methanol:water (1:1, v/v) (100 ml) and the eluate evaporated. The residue was separated on a silica gel column (20 g), prepacked in ethyl acetate. Elution of the column with ethyl acetate (100 ml) and ethyl acetate:methanol (8:2, v/v) (300 ml) afforded 0.118 g (37%) of **8b**, mp 164-165° (ethyl acetate) and 0.112 g (36%) of **4b**, mp 191-193° dec (ethanol).

Reaction of 3,5-Dimethoxy-6-methyl-1,2,4-triazine (**1e**) with Methyl Iodide.

A solution of **1e** (1.55 g, 10 mmoles) in methyl iodide (20 ml) was kept for 48 hours at room temperature in a dark place. The yellow precipitate was collected and air-dried to give 0.121 g (4%) of **2e**, mp 107-108° dec.

Anal. Calcd. for $C_7H_{12}IN_3O_2$ (297.1): C, 28.30; H, 4.07; I, 42.72; N, 14.15. Found: C, 28.39; H, 4.22; I, 43.10; N, 14.41.

The mother liquors remaining after isolation of **2e** were evaporated and the residue was separated on a silica gel column (100 g). Successive elution of the column with 500 ml portions of benzene:ethyl acetate (8:2 and 1:1, v/v), ethyl acetate and ethyl acetate:methanol (8:2 and 7:3, v/v) gave the following products:

Triazinone **7c** (1.085 g, 70%) had mp 122° (benzene-petroleum ether), Rf 0.48 (S1).

Anal. Calcd. for $C_6H_9N_3O_2$ (155.2): C, 46.44; H, 5.85; N, 27.08. Found: C, 46.62; H, 6.08; N, 27.33.

Triazinone **8c** (0.070 g, 4%) had mp 143-146° (benzene-

petroleum ether), Rf 0.23 (S1).

Anal. Calcd. for $C_6H_9N_3O_2$ (155.2): C, 46.44; H, 5.85; N, 27.08. Found: C, 46.59; H, 5.99; N, 27.15.

Triaziniumolate **6b** (0.185 g, 12%) had mp 153-154° (ethanol-petroleum ether), Rf 0.02 (S1) and 0.25 (S2).

Anal. Calcd. for $C_6H_9N_3O_2$ (155.2): C 46.44; H 5.85; N, 27.08. Found: C, 46.55; H, 6.02; N, 27.34.

3-Methoxy-1,6-dimethyl-1,2,4-triazinium-5-olate (**4c**).

A mixture of **2e** (0.297 g, 1 mmole), water (5 ml) and silver carbonate (0.276 g, 1 mmole) was magnetically stirred for 20 minutes at room temperature. The insoluble material was filtered off by suction, the filtrate evaporated, the residue triturated with hot ethanol (15 ml) and the solution filtered with charcoal. Evaporation of the filtrate and trituration of the residue with ethyl acetate gave 0.120 g (77%) of **4c**, mp 138-140° (ethanol-ethyl acetate).

Anal. Calcd. for $C_8H_{12}N_3O_2$ (155.2): C, 46.44; H, 5.85; N, 27.08. Found: C, 46.52; H, 5.81; N, 27.25.

Reaction of 5-Methoxy-6-methyl-3-methylthio-1,2,4-triazine (**1f**) with Methyl Iodide.

A solution of **1f** (0.513 g, 3 mmoles) in methyl iodide (8 ml) was allowed to stand at room temperature for 5 days in a dark place. The orange precipitate was collected and recrystallized from ethanol to give 0.241 g (26%) of **5f**, mp 214-215° dec.

Anal. Calcd. for $C_7H_{12}IN_3OS$ (313.2): C, 26.85; H, 3.86; I, 40.52; N, 13.42. Found: C, 27.09; H, 3.83; I, 40.25; N, 13.65.

The mother liquors remaining after isolation of crude **5f** were evaporated and the residue purified on an alumina column (10 g). Elution of the column with benzene:ethyl acetate (3:2, v/v) gave 0.322 g (63%) of **8d**, mp 108-109° (benzene-petroleum ether) (lit [18] 105-107°).

5-Methoxy-1,6-dimethyl-3-methylthio-1,2,4-triazinium Iodide (**2f**).

A solution of **1f** (1.712 g, 10 mmoles) in methyl iodide (20 ml) was kept for 24 hours at room temperature in a dark place. The orange precipitate was collected and air-dried to give 0.595 g (19%) of **2f**, mp 107-109° dec.

Anal. Calcd. for $C_7H_{12}IN_3OS$ (313.2): C, 26.85; H, 3.86; I, 40.52; N, 13.42. Found: C, 27.00; H, 3.82; I, 40.28; N, 13.25.

1,6-Dimethyl-3-methylthio-1,2,4-triazinium-5-olate (**4d**).

Triazinium iodide **2f** (0.313 g, 1 mmole) was reacted with silver carbonate in analogy to the preparation of **4c** to give 0.055 g (32%) of **4d**, mp 120-122° (methanol-ethyl acetate) (lit [10] 121-122°).

Reaction of 6-Methyl-3,5-bis(methylthio)-1,2,4-triazine (**1g**) with Methyl Iodide.

A solution of **1g** (1.87 g, 10 mmoles) in methyl iodide (25 ml) was allowed to stand for 6 days at room temperature in a dark place. The red crystals were collected and air-dried to give 3.25 g (99%) of a 1:1.9 mixture (estimated by 1H nmr spectra) of **2g** and **3g**, mp 164-174° dec.

Anal. Calcd. for $C_7H_{12}IN_3S_2$ (329.2): C, 25.53; H, 3.68; I, 38.56; N, 12.76. Found: C, 25.21; H, 3.71; I, 38.30; N, 12.46.

Hydrolysis of the Mixture of Isomeric Dimethyl-3,5-bis(methylthio)-1,2,4-triazinium Iodides **2g** and **3g**.

A mixture of **2g** and **3g** (0.662 g, 2 mmoles) was hydrolyzed and worked up in the same way as described for the hydrolysis of **2d** and **3d**. Separation of the crude product on a silica gel column gave 0.212 g (62%) of **8d**, mp 107-109° (ethyl acetate-petroleum ether) and 0.054 g (16%) of **4d**, mp 120-122° (methanol-ethyl acetate).

Acknowledgement.

This work was partially supported by the Grant Agency of the Czech Academy of Sciences (Grant No. 45 515). The authors are indebted to the staff of the Analytical Laboratory (Dr. V. Pechanec, Head) for elemental analyses and the staff of the Central Laboratory of Mass Spectrometry (Dr. K. Ubik, Head) for the mass spectral data. The excellent technical assistance of Mrs. Y. Černá is gratefully acknowledged.

REFERENCES AND NOTES

- [1] J. Gut, V. Uchytílová, M. Prystaš, A. Nováček and P. Fiedler, IVth Symposium on the Chemistry of Heterocyclic Compounds, Summaries, B-25, p 83, Usti nad Labem, May 1972.
- [2] M. Prystaš, V. Uchytílová and J. Gut, *Collect. Czech. Chem. Commun.*, **38**, 934 (1973).
- [3] A. Pískala and P. Fiedler, IVth Symposium on the Chemistry of Heterocyclic Compounds, Summaries, B-26, p 84, Ústí nad Labem, May 1972.
- [4] G. Doleschall and K. Lempert, *Tetrahedron*, **32**, 1735 (1976).
- [5] A. Kakehi, S. Ito, K. Uchiyama and Y. Komo, *Chem. Letters*, 413 (1976).
- [6] S. Bátori, A. Messmer, P. Benko and L. Pallos, The VIIth Symposium on Chemistry of Heterocyclic Compounds, Abstracts of papers, p 116, Bratislava, September 1981.
- [7] A. Messmer, S. Bátori, Zs. Juhasz-Riedl and Gy. Hájos, *Bull. Soc. Chim. Belg.*, **91**, 412 (1982)
- [8] S. Bátori, A. Messmer and Zs. Juhasz-Riedl *Nucleic Acids, Symp. Ser. No 14*, 179 (1984).
- [9] N. W. Jacobsen and S. E. Rose, *Aust. J. Chem.*, **38**, 1809 (1985)
- [10] N. W. Jacobsen and S. B. Rose, *Aust. J. Chem.*, **40**, 967 (1987).
- [11] N. W. Jacobsen and S. E. Rose, *Aust. J. Chem.*, **41**, 609 (1988).
- [12] A. Pískala and J. Gut, in *Studies in Organic Chemistry 35, Chemistry of Heterocyclic Compounds*, J. Kováč and P. Zálupský, eds, Elsevier, Amsterdam, 1988, pp 476-478.
- [13] G. E. Hilbert and T. B. Johnson, *J. Am. Chem. Soc.*, **52**, 2001 (1930).
- [14] G. E. Hilbert and T. B. Johnson, *J. Am. Chem. Soc.* **52**, 4489 (1930).
- [15] J. Pliml and M. Prystaš, *Advan. Heterocyclic Chem.*, **8**, 115 (1967).
- [16] T. L. V. Ulbricht, *J. Chem. Soc.*, 3345 (1961).
- [17] J. Gut, M. Prystaš, J. Jonáš and F. Šorm, *Collect. Czech. Chem. Commun.*, **26**, 974 (1961).
- [18] M. Prystaš, J. Gut and J. Jonáš, *Collect. Czech. Chem. Commun.*, **26**, 986 (1961)
- [19] C. M. Atkinson and H. D. Cossey, *J. Chem. Soc.*, 1628 (1963).
- [20] N. W. Jacobsen and I. de Jonge, *Aust. J. Chem.*, **40**, 1979 (1987).
- [21] A. Pískala, *Collect. Czech. Chem. Commun.*, **40**, 2340 (1975).
- [22] A. Pískala, P. Fiedler, M. Synácková and J. Gut, *Collect. Czech. Chem. Commun.*, **40**, 2326 (1975).
- [23] J. Jonáš and J. Gut, *Collect. Czech. Chem. Commun.*, **27**, 1886 (1962).
- [24] J. Jonáš and J. Gut, *Collect. Czech. Chem. Commun.*, **26**, 2155 (1961).
- [25] D. J. Brown and R. L. Jones, *Aust. J. Chem.*, **25**, 2711 (1972).
- [26] M. Horák and J. Gut, *Collect. Czech. Chem. Commun.*, **26**, 1680 (1961).
- [27] A. Pískala, unpublished results.
- [28] Unless stated otherwise, the compounds displayed their protons as singlets.