

Isothiocyanates. XXXI.
Synthesis, Ultraviolet and Infrared Spectra of 3-Substituted
2-Thiohydantoins and N-Substituted Ethyl
Thiocarbamoylmercaptoacetates

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The preparation, ultraviolet and infrared spectra of 3-aryl- and aralkyl-2-thiohydantoins as well as *N*-aryl- and *N*-aralkylthiocarbamoylmercaptoacetic acids and their ethyl esters are described. Both types of the above-mentioned substances are synthetic producers of the corresponding aryl or aralkyl isothiocyanates. *N*-Substituted ethyl thiocarbamoylmercaptoacetates are new, hitherto not described substances.

3-Substituted 2-thiohydantoins described in this paper were prepared on the basis of previous studies of the kinetics of nucleophilic addition reaction of glycine to isothiocyanates and their cyclization in acid medium [1] to give the corresponding thiocarbamoyl derivatives.

N-Substituted ethyl thiocarbamoylmercaptoacetates (*IX*–*XIII*) were prepared by condensation of *N*-substituted dithiocarbamates with ethyl chloroacetate by method used for preparation of ethyl *N*-phenylthiocarbamoylmercaptoacetate [2]. These substances could be prepared also by the nucleophilic addition of ethyl thioglycolate to isothiocyanates under analogous conditions as when investigating kinetics of isothiocyanate with thioglycolate [3]. In this case, however, the reaction products are *N*-substituted thiocarbamoylmercaptoacetic acids, the isolation of which is rather difficult because of their ability to cyclize and furnish the corresponding 3-substituted rhodanines, or decompose to yield isothiocyanates [4, 5]. Addition products resulting from the reaction of relatively less reactive isothiocyanates are more stable; this fact accounts for the preparation of two derivatives with free carboxyl group: *N*-benzyl- and *N*-(*p*-bromobenzyl)thiocarbamoylmercaptoacetic acids.

3-Substituted 2-thiohydantoins as well as *N*-substituted ethyl thiocarbamoylmercaptoacetates could be considered synthetic producers of isothiocyanates, *i.e.* substances, which liberate isothiocyanates. This paper deals with their preparation and also with their ultraviolet and infrared spectra.

Experimental

Infrared absorption spectra of the synthesized substances were measured in 0.05 M chloroform solutions with a double-beam UR-10 (Zeiss, Jena) spectrophotometer in the

700—3600 cm^{-1} range. LiF prism and NaCl cells 0.147 mm in width were used. Ultraviolet absorption spectra were taken with a VSU-1 (Zeiss, Jena) spectrophotometer in the 220—360 nm range. Methanolic solutions (2.5×10^{-5} M to 5×10^{-5} M) were measured in 10-mm cells.

3-Substituted 2-thiohydantoins

The title compounds were prepared by a modified method reported by Pujari [6]. The appropriate isothiocyanate (0.13 mole) was dissolved in ethanol (50 ml) and added to a mixture of glycine (0.14 mole) and NaOH (9 g in 20 ml of water). After 1 hour of refluxing, during which a yellow substance was separated, the excess of ethanol was distilled off, the distillation residue dissolved in concentrated hydrochloric acid and evaporated to dryness. The solid was washed with water and crystallized from a suitable solvent. Physicochemical constants of 3-substituted 2-thiohydantoins prepared according to this process are listed in Table 1.

Table 1

3-R-2-Thiohydantoins

| No. | R | Formula | M | Calculated/ found | | Yield [%] | M.p. [°C] |
|------|--------------------------------|--|--------|----------------------|----------------|--------------|------------------------|
| | | | | % N | % S | | |
| I | phenyl- | $\text{C}_9\text{H}_8\text{N}_2\text{OS}$ | 192.23 | — | — | 60.5 | 245—247 |
| II | <i>p</i> -bromophenyl- | $\text{C}_9\text{H}_7\text{BrN}_2\text{OS}$ | 271.13 | — | — | 54.3 | 238 |
| III | <i>p</i> -tolyl- | $\text{C}_{10}\text{H}_{10}\text{N}_2\text{OS}$ | 206.26 | — | — | 62.1 | 235—236 |
| IV | <i>p</i> -nitrophenyl- | $\text{C}_9\text{H}_7\text{N}_3\text{O}_3\text{S}$ | 237.23 | — | — | 49.5 | 170—172 |
| V | <i>p</i> -methoxyphenyl- | $\text{C}_{10}\text{H}_{10}\text{N}_2\text{O}_2\text{S}$ | 222.26 | — | — | 58.5 | 212—214 |
| VI | <i>p</i> -dimethylaminophenyl- | $\text{C}_{11}\text{H}_{13}\text{N}_3\text{OS}$ | 235.30 | 17.85 17.35 | 13.60 13.20 | 56.3 | 172—174 |
| VII | <i>p</i> -acetylphenyl- | $\text{C}_{11}\text{H}_{10}\text{N}_2\text{O}_2\text{S}$ | 234.27 | 11.95 11.71 | 13.68 13.20 | 50.1 | 274—275 |
| VIII | benzyl- | $\text{C}_{10}\text{H}_{10}\text{N}_2\text{OS}$ | 206.26 | 13.58 13.48 | 15.54 15.70 | 49.2 | 173—174.5 ^a |

a) In [7] the m.p. is reported to be 128°C.

N-Substituted thiocarbamoylmercaptoacetic acids and their esters

The title compounds were synthesized by a modified method described by von Braun [2].

Ethyl monochloroacetate (0.1 mole, 12.4 g) was gradually added, whilst vigorously stirred and cooled with ice, to an *N*-substituted ammonium dithiocarbamate (0.1 mole). Stirring was continued for 1 to 2 hours during which a pasty material was formed. The solid was washed several times with cold water and crystallized from ether.

Besides the above-mentioned esters also *N*-benzyl- and *N*-(*p*-bromobenzyl)thiocarbamoylmercaptoacetic acids were prepared similarly using free monochloroacetic acid.

Table 2

N-Substituted thiocarbamoylmercaptoacetic acids (XIV, XV) and ethyl
N-R-thiocarbamoylmercaptoacetates (IX–XIII)

| No. | R | Formula | <i>M</i> | Calculated/ found | | Yield [%] | M.p. [°C] |
|-------------|--------------------------------|--|----------|----------------------|----------------|--------------|--------------|
| | | | | % N | % S | | |
| <i>IX</i> | benzyl- | C ₁₂ H ₁₅ NO ₂ S ₂ | 269.38 | 5.19 5.38 | 23.81 24.20 | 48.5 | 80–81 |
| <i>X</i> | <i>p</i> -tolyl- | C ₁₂ H ₁₅ NO ₂ S ₂ | 269.38 | 5.19 5.28 | 23.81 24.24 | 38.0 | 75–77 |
| <i>XI</i> | <i>p</i> -bromophenyl- | C ₁₁ H ₁₂ BrNO ₂ S ₂ | 334.25 | 4.19 4.33 | 19.18 19.16 | 42.1 | 80–82 |
| <i>XII</i> | <i>p</i> -dimethylaminophenyl- | C ₁₃ H ₁₈ N ₂ O ₂ S ₂ | 298.42 | 9.38 9.40 | 21.48 21.85 | 33.1 | 105–106 |
| <i>XIII</i> | <i>p</i> -methoxyphenyl- | C ₁₂ H ₁₅ NO ₃ S ₂ | 285.38 | 4.20 4.32 | 22.47 22.81 | 45.2 | 104–105 |
| <i>XIV</i> | benzyl- | C ₁₀ H ₁₁ NO ₂ S ₂ | 241.33 | — | — | 54.5 | 88–90 |
| <i>XV</i> | <i>p</i> -bromobenzyl- | C ₁₀ H ₁₀ BrNO ₂ S ₂ | 320.10 | 4.37 4.52 | 20.02 20.30 | 48.5 | 119–120 |

Table 3

Characteristic u.v. and i.r. spectral data of 3-substituted 2-thiohydantoin

| No. | R | $\lambda_{\max \text{ I}}$ [nm] | log ϵ | $\tilde{\nu}(\text{C}=\text{O})$ [cm ⁻¹] |
|-------------|--------------------------------|------------------------------------|----------------|---|
| <i>I</i> | phenyl- | 264 | 4.29 | 1768 |
| <i>II</i> | <i>p</i> -bromophenyl- | 264 | 4.15 | 1771 |
| <i>III</i> | <i>p</i> -tolyl- | 266 | 4.29 | 1758 |
| <i>IV</i> | <i>p</i> -nitrophenyl- | 236 | 4.10 | 1642 |
| <i>V</i> | <i>p</i> -methoxyphenyl- | 264 | 4.28 | 1769 |
| <i>VI</i> | <i>p</i> -dimethylaminophenyl- | 262 | 4.42 | 1751 |
| <i>VII</i> | <i>p</i> -acetylphenyl- | 246 | 4.34 | 1690 |
| <i>VIII</i> | benzyl- | 264 | 4.23 | 1756 1760 |

$\lambda_{\max \text{ II}}$ of derivative *IV* — 334 nm (log ϵ 4.29).

Table 4

Characteristic u.v. and i.r. spectral data of *N*-substituted thiocarbamoylmercaptoacetic
acids and their esters

| No. | R | $\lambda_{\max \text{ I}}$ [nm] | log ϵ | $\lambda_{\max \text{ II}}$ [nm] | log ϵ | $\tilde{\nu}(\text{C}=\text{O})$ [cm ⁻¹] |
|-------------|--------------------------------|------------------------------------|----------------|-------------------------------------|----------------|---|
| <i>IX</i> | benzyl- | 250 | 4.02 | 270 | 3.93 | 1744 |
| <i>X</i> | <i>p</i> -tolyl- | 276 | 4.19 | — | — | 1734 |
| <i>XI</i> | <i>p</i> -bromophenyl- | 276 | 4.29 | 305 sh | 4.21 | 1735 |
| <i>XII</i> | <i>p</i> -dimethylaminophenyl- | 264 | 4.24 | 300 sh | 4.12 | 1732–1740 |
| <i>XIII</i> | <i>p</i> -methoxyphenyl- | 290 | 4.10 | — | — | 1735–1745 |
| <i>XIV</i> | benzyl- | 252 | 4.03 | 276 | 4.02 | 1735 |
| <i>XV</i> | <i>p</i> -bromobenzyl- | 250 | 4.09 | 276 | 4.01 | 1738 |

Derivatives *XIV* and *XV* are *N*-substituted thiocarbamoylmercaptoacetic acids.
sh — shoulder.

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