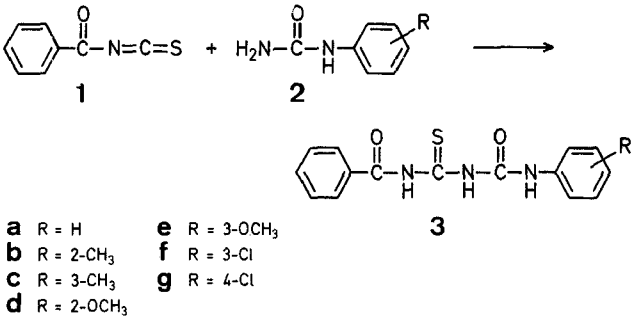
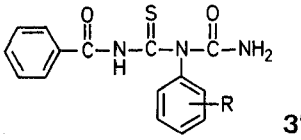


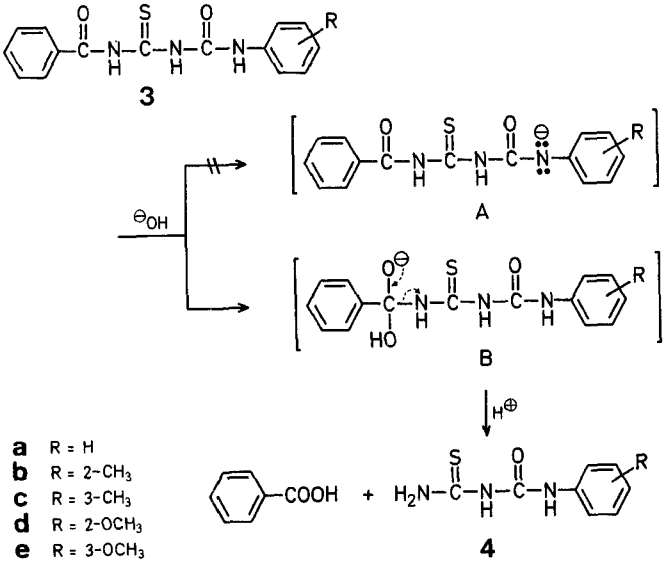
a R = H **e** R = 3-OCH_3
b R = 2-CH_3 **f** R = 3-Cl
c R = 3-CH_3 **g** R = 4-Cl
d R = 2-OCH_3

The I.R. spectra of **3** (Table 1) support the assigned structure (cf. Ref.[1]); the absence of a band at $\nu = 2570\ cm^{-1}$ suggests that compounds **3** exist in the thioxo form (thiolactam form).

The alternative structure **3'** was ruled out by the finding that *N,N'*-diphenylurea does not react with **1** and by comparison of the melting point of **3a** with the literature value[2]. The electronic spectra of compounds **3b–g** were similar to that of **3a**.



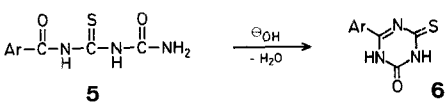
Further, alkaline hydrolysis of **3a** with 1 normal or 4 normal aqueous sodium hydroxide in ethanol (16 h) followed by acidification afforded 5-phenyl-2-thiobiuret **(4a)** which was identical (m.p. and mixture m.p.) with authentic **4a** prepared from thiourea and phenyl isocyanate[3].



a R = H
b R = 2-CH_3
c R = 3-CH_3
d R = 2-OCH_3
e R = 3-OCH_3

The hitherto unknown 5-aryl-2-thiobiurets **4b–e** were obtained in analytically pure form. Their electronic spectra are similar to that of **4a** (Table 2). The I.R. spectra of compounds **4** further support the assigned structure.

The alkaline hydrolysis of 5-aryl-1-benzoyl-2-thiobiurets **(3)** proceeds via the intermediate anion B; the alternative intermediate anion A can be ruled out since it can be regarded as a strong nucleophile which should undergo ring closure via attack of the benzoyl C=O group by the anionic N-atom. Such a ring closure occurs when 1-aroyl-2-thiobiurets **(5)**



Isothiocyanates; II[1]. The Addition of Arylureas to Benzoyl Isothiocyanate and the Synthesis of 5-Aryl-2-thiobiurets and 2-Aryl-5-benzoylamino-3-oxo-2,3-dihydro-1,2,4-thiadiazoles

Mohamed N. Basyouni*, Abdel-Momen A. El-Khamry, Mohamed M. Habashy, Mohamed E. Shaban, Mostafa M. El-Adly

Chemistry Department, Faculty of Science, Ain Shams University, Abassia, Cairo, Egypt

We have shown[1] that the addition of urea to a number of aroyl isothiocyanates of various electrophilicity proceeds via exclusive attack on the C=S function of the isothiocyanates. The present work was undertaken to establish the mode of addition of arylureas, either by the NH_2 or the NH—Ar group, to the C=S group of benzoyl isothiocyanate and to study the reaction of the monoadducts thus obtained with alkali metal hydroxides, hydrogen peroxide, and bromine. We found that the addition of arylureas **(2)** to benzoyl isothiocyanate **(1)** in dry acetone affords good yields of 5-aryl-1-benzoyl-2-thiobiurets **(3)**, i.e., that the free NH_2 group of **2** adds to the C=S group of **1**.

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Table 1. 5-Aryl-1-benzoyl-2-thiobiurets (**3a–g**)

3	Yield [%]	m.p. [°C] (solvent)	Molecular formula[a]	I.R. (KBr) ν [cm^{-1}]	U.V. (dioxan) λ_{max} [nm] (log ε)
a	90	177–179°[b] (ethanol)	(m.p. 179 °C)[2]	3300, 3280, 3250, 3200, 3140 (NH); 1715, 1680, 1620 (C=O)	244 (4.36), 281 (4.21)
b	85	167–168° (ethanol)	$C_{16}H_{15}N_3O_2S$ (313.4)	3280, 3220, 3180, 3160, 3130 (NH); 1720, 1680, 1620 (C=O)	242 (4.31), 280 (4.16)
c	90	163–164° (benzene)	$C_{16}H_{15}N_3O_2S$ (313.4)	3290, 3230, 3200, 3160, 3130 (NH); 1715, 1675, 1620 (C=O)	241 (4.30), 279 (4.15)
d	87	190–191° (ethanol)	$C_{16}H_{15}N_3O_3S$ (329.4)	3280, 3230, 3200, 3150, 3120 (NH); 1720, 1680, 1615 (C=O)	245 (4.38), 283 (4.23)
e	92	153–155° (ethanol)	$C_{16}H_{15}N_3O_3S$ (329.4)	3260, 3230, 3200, 3150, 3120 (NH); 1720, 1680, 1620 (C=O)	240 (4.29), 280 (4.19)
f	83	188–190° (ethanol)	$C_{15}H_{12}ClN_3O_2S$ (333.7)	3280, 3250, 3180, 3160, 3120 (NH); 1720, 1680, 1620 (C=O)	241 (4.31), 280 (4.17)
g	80	184–186° (toluene)	$C_{15}H_{12}ClN_3O_2S$ (333.7)	3280, 3260, 3200, 3160, 3120 (NH); 1720, 1680, 1620 (C=O)	242 (4.32), 282 (4.21)

[a] The microanalyses were in satisfactory agreement with the calculated values: C, ±0.34; H, ±0.32; N, ±0.32; S, ±0.32.

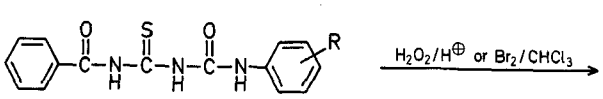
Table 2. 5-Aryl-2-thiobiurets (**4a–e**)

4	Yield [%]	m.p. [°C] (solvent)	Molecular formula[a]	I.R. (KBr) ν [cm^{-1}]	U.V. (dioxan) λ_{max} [nm] (log ε)
a	95	185–186° (ethanol)	(m.p. 186 °C)[5]	3380, 3320, 3290, 3250, 3160, 3140 (NH); 1720, 1710, 1620 (C=O)	272 (4.13)
b	90	132–134° (water)	$C_9H_{11}N_3OS$ (209.3)	3480, 3460, 3340, 3320, 3260, 3160 (NH); 1720, 1710, 1625 (C=O)	273 (4.14)
c	88	204–205° (ethanol/water)	$C_9H_{11}N_3OS$ (209.3)	3480, 3460, 3320, 3260, 3180 (NH); 1720, 1710, 1620 (C=O)	269 (4.10)
d	94	188–190° (ethanol/water)	$C_9H_{11}N_3O_2S$ (225.3)	3480, 3450, 3340, 3320, 3260, 3160 (NH); 1720, 1710, 1625 (C=O)	274 (4.15)
e	90	146–147° (ethanol/water)	$C_9H_{11}N_3O_2S$ (225.3)	3480, 3460, 3340, 3320, 3280, 3160 (NH); 1720, 1710, 1620 (C=O)	270 (4.11)

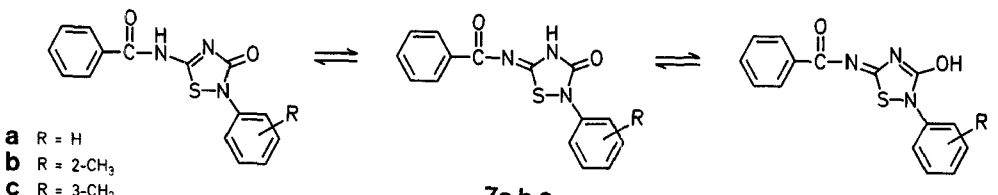
[a] The microanalyses were in satisfactory agreement with the calculated values: C, ±0.32; H, ±0.25; N, ±0.31; S, ±0.24.

are treated with aqueous alkali; in this case, an 1,3,5-triazine derivative (**6**) is formed via an intermediate analogous to intermediate A.

Treatment of the 5-aryl-1-benzoyl-2-thiobiurets **3a, b, e** with hydrogen peroxide/hydrochloric acid effects cyclodehydrogenation to afford 2-aryl-5-benzoylamino-3-oxo-2,3-dihydro-1,2,4-thiadiazoles (**7a, b, e**) or their tautomers. Compounds **7a, b, e** are isolated in pure form.



3a,b,e



a R = H
b R = 2-CH_3
c R = 3-CH_3

7a,b,e

The structure of compounds **7a, b, e** was confirmed by microanalyses and by I.R.- and U.V.-spectral data (Table 3). Compounds **7a, b, e** are relatively stable towards aqueous sodium plumbite whereas their precursors **3** give rise to immediate lead sulfide formation when treated with the same reagent.

Compound **3a** may also be cyclodehydrogenated to **7a** using bromine in chloroform.

5-Aryl-1-benzoyl-2-thiobiurets (3); General Procedure:

A solution or suspension of the arylurea (**2**; 0.05 mol) in dry acetone (50 ml) is added portionwise to a stirred solution of benzoyl isothiocyanate (**1**; 8.15 g, 0.05 mol) in dry acetone (100 ml). The mixture is then refluxed for 2–3 h until the arylurea has completely dissolved. The acetone is evaporated and the residue triturated with hot water to give a crystalline solid which is recrystallized from ethanol, benzene, or toluene to give the pure thiobiuret **2**.

Attempted Addition of *N,N'*-Diphenylurea to Benzoyl Isothiocyanate:

N,N'-Diphenylurea (2.12 g, 0.01 mol) in dry acetone (100 ml) was added portionwise with stirring to benzoyl isothiocyanate (**1**; 1.63 g, 0.01 mol) in dry acetone (100 ml)

Table 3. 2-Aryl-5-benzoylamino-3-oxo-2,3-dihydro-1,2,4-thiadiazoles (**7a, b, c**)

7	Yield [%]	m.p. [°C] (solvent)	Molecular formula[a]	I.R. (KBr) ν [cm^{-1}]	U.V. (dioxan) λ_{max} [nm] (log ε)
a	87	225–228° (ethanol)	$C_{15}H_{11}N_3O_2S$ (297.3)	broad band at 3230–3100 (NH and/or OH); 1710, 1670, 1650 (C=O)	246 (4.35), 329 (4.07)
b	76	207–209° (ethanol/water)	$C_{16}H_{13}N_3O_2S$ (311.4)	broad band at 3220–3100 (NH and/or OH); 1710, 1670, 1640 (C=O)	234 (4.62), 331 (4.18)
c	80	222–224° (ethanol)	$C_{16}H_{13}N_3O_3S$ (327.4)	broad band at 3225–3100 (NH and/or OH); 1710, 1670, 1645 (C=O)	235 (4.63), 328 (4.09)

[a] The microanalyses were in satisfactory agreement with the calculated values: C, ±0.30; H, ±0.31; N, ±0.22; S, −0.11.

and the reaction mixture was refluxed for 3 h. Evaporation of the acetone solution followed by trituration of the residue with hot water gave a crystalline solid which was recrystallized from ethyl acetate to give unchanged *N,N'*-diphenylurea (m.p. and mixture m.p. 242 °C) in ~98% recovery.

5-Aryl-2-thiobiurets (4a–e); General Procedure:

A solution of the 5-aryl-1-benzoyl-2-thiobiuret (**3**; 0.01 mol) in aqueous 4 normal (or 1 normal) sodium hydroxide (60 ml) and ethanol (30 ml) is allowed to stand at room temperature for 16 h, and then acidified to pH ~6 with 2 normal sulfuric acid. The resultant precipitate is isolated by suction and recrystallized from ethanol, water, or aqueous ethanol to give the pure product **4**.

2-Aryl-5-benzoylamino-3-oxo-2,3-dihydro-1,2,4-thiadiazoles (7a, b, e):

Method A, General Procedure using Hydrogen Peroxide/Hydrochloric Acid: To a boiling solution of the 5-aryl-1-benzoyl-2-thiobiuret (**3a, b, e**; 0.01 mol) in ethanol (30 ml) containing concentrated hydrochloric acid (1 ml) is added 10% hydrogen peroxide (15 ml) over a 5 min period. The mixture is then allowed to cool to room temperature, the precipitated solid isolated by suction, and recrystallized from ethanol or ethanol/water to give the pure product **7**.

Method B, using Bromine in Chloroform: A solution of bromine (1.6 g, 0.01 mol) in chloroform (5 ml) is added dropwise to a stirred solution of 1-benzoyl-5-phenyl-2-thiobiuret (**3a**; 3 g, 0.01 mol) in ethanol (30 ml) at 40–45 °C. The mixture is then concentrated in vacuo at low temperature, the precipitated solid isolated by suction, and recrystallized from ethanol to give *5-benzoylamino-3-oxo-2-phenyl-2,3-dihydro-1,2,4-thiadiazole* (**7a**); yield: 2.4 g (81%); m.p. 225–228 °C [mixture m.p. with product **7a** obtained by Method A: 225–228 °C].

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* Address for correspondence.

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