Acetylenic Ketones. Part V (1). Reaction of Acetylenic Ketones with Thiourea and some of its Derivatives

F. G. Baddar, F. H. Al-Hajjar and N. R. El-Rayyes*

Department of Chemistry, Kuwait University, Kuwait

Received July 5, 1977

Aroylphenylacetylenes (I) reacted with thiourea and *S*-benzylisothiourea to give 4,6-diarylpyrimidine-2(1*H*)thiones (IV) and α-aroyl-β-benzylmercaptostyrenes (X), respectively. Methylation and acetylation of the thiones (IV) gave the corresponding *S*-methyl- (V) and *S*-acetyl- (VI) derivatives, respectively. The oxidation of these thiones gave the corresponding disulfide derivatives (VII). Reaction of α-aroyl-β-benzylmercaptostyrenes (X) with hydrazine hydrate and phenylhydrazine gave 3(5)-aryl-5(3)-phenylpyrazoles (XI) and 3-aryl-1,5-diphenylpyrazoles (XIII), respectively. Reaction of aroylphenylacetylenes (I) with *N*-allylthiourea gave 1-allyl-4,6-diarylpyrimidine-2-thiones (XVI).

J. Heterocyclic Chem., 15, 105 (1978)

The present study is an extension of the previous work (2), and involves the reaction of aroylarylacetylenes (I) with thiourea, *S*-benzylisothiourea and *N*-allylthiourea.

Reaction of Acetylenic Ketones with Thiourea.

When benzoyl- (Ia), *p*-toluyl- (Ib), *m*-chlorobenzoyl- (Ic), *p*-chlorobenzoyl- (Id), *p*-methoxybenzoyl- (Ie) and 3,4-methylenedioxybenzoyl- (If) phenylacetylenes were allowed to react with thiourea in the presence of sodium ethoxide in ethanol, they gave rise to the corresponding 4(6)-aryl-6(4)-phenylpyrimidine-2(1*H*)thiones (IVa-f). The products (IVd,e) were also obtained when benzoyl-*p*-chlorophenyl- (Ig) and benzoyl-*p*-methoxyphenyl- (Ih) acetylenes were used instead of *p*-chlorobenzoyl- (Id) and *p*-methoxybenzoyl- (Ie) phenylacetylenes, respectively. The reaction seems to proceed by Michael addition of the anion II, derived from thiourea, to the aroylphenylacetylene followed by cyclization of the intermediate III (2) (*cf.* Scheme 1).

Scheme I

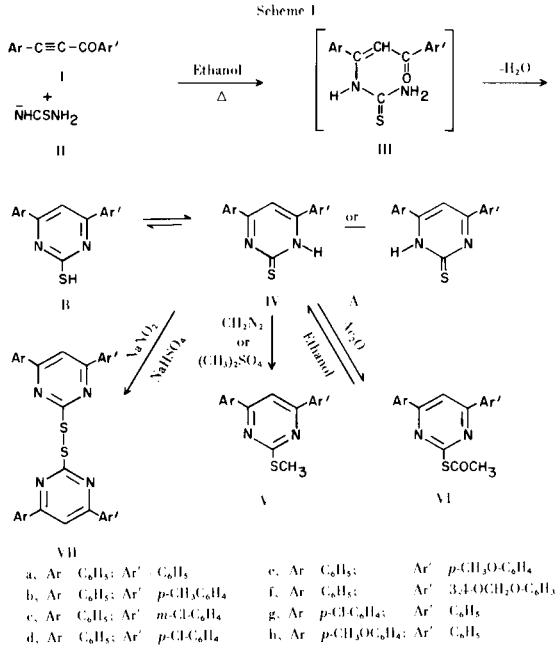


Table I

Infrared and Nuclear Magnetic Resonance Spectral Data of 4,6-Diarylpyrimidine-2(1*H*)thiones (IVa-f)

Compound No.	Infrared Spectra (Potassium bromide) cm^{-1}	ν	Nmr Spectra (Deuteriochloroform and DMSO) δ	Assignments (No. of protons)
IVa	1602 (s)	C=N	7.9 (s)	(1) -CH=
	1550 (s)	C=C	7.21-8.23 (m)	(11) Ar*H* + N*H*
IVb	1611 (s)	C=N	7.93 (s)	(1) -CH=
	1548 (s)	C=C	7.23-8.23 (m)	(10) Ar*H* + N*H*
			2.4 (s)	(3) ArCH_3
IVc	1608 (s)	C=N	8.0-8.23 (m)	(4) Ar*H*
	1550 (s)	C=C	7.57-7.80 (m)	(7) C_6H_5 + -C*H*= + N*H*
	1549 (s)			
IVd	1605 (s)	C=N	7.9-8.23 (m)	(4) Ar*H*
	1575 (s)	C=C	7.67 (s)	(1) -C*H*=
	1548 (s)		7.33-7.63 (m)	(6) C_6H_5 + N*H*
IVe	1604 (s)	C=N	6.93-8.2 (m)	(11) Ar*H* + -C*H*= + N*H*
	1545 (s)	C=C	3.85 (s)	(3) ArOCH_3
IVf	1590 (s)	C=N	7.0-8.23 (m)	(9) Ar*H* + N*H*
	1545 (s)	C=C	7.53 (s)	(1) -C*H*=
			6.23 (s)	(2) -OCH_2O-

Table II

Electronic Spectra of 4,6-Diarylpyrimidine-2(1*H*)thiones (IVa-f)

Compound No.	Ethanol λ max (nm)	Ethanol ε max	Cyclohexane λ max (nm)	Cyclohexane ε max
IVa	404	1,900	319	11,920
	297	24,370	257	32,450
	266	21,060		
	245-237 (sh)	18,170		
IVb	408	1,300	321	12,850
	300	30,160	260	29,440
	248	17,630	238-232 (sh)	19,270
IVc	412	2,240	322	11,200
	296	21,010	257	33,610
	263	21,575	238-233 (sh)	24,890
	245-239 (sh)	20,320		
IVd	406	2,180	323	11,580
	297-285 (sh)	20,230	295-292 (sh)	7,470
	270	20,850	262	29,500
	247	18,670		
IVe	450	4,830	326	23,060
	330-321 (sh)	17,020	268 (a)	21,100
	297	31,740	258 (a)	31,400
	248	18,860	233	25,530
IVf	430-400 (sh)	4,240	330	13,390
	345	9,630		
	299	23,510	258-248	14,900
	240-227 (sh)	21,580	238	16,400

(a) Fine structure.

The structure of the thiones (IVa-f) was established by spectroscopic evidence. Thus, their ir spectra are devoid of ν S-H and show two bands at 1611-1590 cm^{-1} (ν C=N) (3a) and 1575-1548 cm^{-1} (ν C=C) (2) (*cf.* Table I). This indicates that these compounds exist predominantly in the thione form (IVA) (thiolactam) rather than in the thiol form (IVB) (4). The thione structure was also substantiated by their electronic spectra in ethanol (*cf.* Table II), which show intense bands in the region 300-240 nm, as well as a low intensity n → π^* transition (=C=S: chromophore) band in the range 430-400 nm. However, when the electronic spectra were measured in cyclohexane they were different from those in ethanol and the n → π^* transition band disappeared, which indicates that IVa-f exist mainly in the thiol form (IVB) in non-polar solvents. This conclusion is substantiated by the fact that their absorption spectra in cyclohexane resemble those of the corresponding disulfides (VII) (*cf.* Table V) with nearly half the molar extinction coefficient. Their nmr spectra show signals corresponding to (-CH=), (NH) and the aromatic protons (*cf.* Table I).

Chemical Reaction of Pyrimidinethiones (IV).

Methylation of these compounds either by diazomethane, or by dimethyl sulfate in the presence of anhydrous potassium carbonate gave the corresponding 4-aryl-6-phenyl-2-methylmercaptopyrimidines (Va-f). The structure of these compounds was inferred from their nmr,

Table III

Nuclear Magnetic Resonance, Infrared and Electronic Spectral Data of 4,6-Diaryl-2-methylmercaptopyrimidines (Va-f)

Compound No.	Nmr Spectra (Deuteriochloroform) δ	Nmr Spectra Assignments (No. of Protons)	Infrared Spectra (Potassium bromide) cm^{-1}	Infrared Spectra ν	Electronic Spectra (Ethanol) λ max (nm)	Electronic Spectra ε max
Va	7.7 (s)	(1) -C*H*=	1572 (s)	Pyrimidine	327	8,830
	7.2-8.2 (m)	(10) Ar*H*	1525 (s)	ring	264	38,400
	2.7 (s)	(3) SCH_3				
Vb	7.72 (s)	(1) -C*H*=	1570 (s)	Pyrimidine	327	8,330
	7.13-8.23 (m)	(9) Ar*H*	1520 (s)	ring	265	28,720
	2.67 (s)	(3) SCH_3				
	2.37 (s)	(3) ArCH_3				
Vc	7.70 (s)	(1) -C*H*=	1568 (s)	Pyrimidine	333	8,890
	7.23-8.27 (m)	(9) Ar*H*	1522 (s)	ring	264	39,100
	2.70 (s)	(3) SCH_3				
Vd	7.67 (s)	(1) -C*H*=	1570 (s)	Pyrimidine	332	10,430
	7.20-8.17 (m)	(9) Ar*H*	1520 (s)	ring	268	41,700
	2.68 (s)	(3) SCH_3				
Ve	7.57 (s)	(1) -C*H*=	1571 (s)	Pyrimidine	333	12,330
	6.83-8.10 (m)	(9) Ar*H*	1522 (s)	ring	284-290 (sh)	14,650
	3.63 (s)	(3) ArOCH_3			263	24,670
	2.63 (s)	(3) SCH_3				
Vf	7.58 (s)	(1) -C*H*=	1570 (s)	Pyrimidine	332	13,450
	6.8-8.23 (m)	(8) Ar*H*	1523 (s)	ring	280-295 (sh)	15,600
	5.98 (s)	(2) OCH_2O			265	26,700
	2.65 (s)	(3) SCH_3				

ir and uv spectra (*cf.* Table III). Thus, their nmr spectra show a sharp signal at δ 2.63-2.70 (3, s, SCH_3) and at δ 7.57-7.72 (1, s, -C*H*=) (2). Their ir spectra show two strong bands at 1572-1568 cm^{-1} and 1525-1520 cm^{-1}, characteristic of the pyrimidine system (2,3b). The electronic spectra of these compounds are identical and show absorption maxima in the range 333-327 nm and 268-263 nm, and they are quite different from those of the corresponding *N*-allyl derivatives (XVI) (*cf.* Table VII). These are $\pi \rightarrow \pi^*$ transition bands corresponding to ^1L_b and ^1L_a bands and are characteristic of the pyrimidine ring (2). The absence of the $n \rightarrow \pi^*$ transition band in the spectra of these compounds is a strong evidence that they are S-CH_3 rather than N-CH_3 derivatives. Acetylation of compounds IVa and IVc with acetic anhydride gave the *S*-acetyl derivatives (VIa,c). This conclusion was inferred from their nmr, ir and uv spectra (*cf.* Table IV). Thus, their nmr spectra show a sharp signal at δ 2.57-2.55 (3, s, $COCH_3$) attributable to $SCOCH_3$ protons. Their ir spectra show a strong band at 1718-1714 cm^{-1} (ν C=O in $SCOCH_3$) (5), in addition to two strong bands at 1578-1573 cm^{-1} and 1518-1515 cm^{-1} attributable to the pyrimidine system (3b). The electronic spectra of these compounds gave a band in the region 310-260 nm ($\pi \rightarrow \pi^*$ transition). Further support for the structure assigned to these compounds was also gained from the mass spectrum of IVa, which shows the molecular radical ion at m/e 306 (7.9%) $[M]^+$ and the fragment ion at m/e 263 (100%) $[M\text{-}COCH_3]^+$ as the base peak, as well as a peak at m/e 231 (8%) $[M\text{-}SCOCH_3]^+$. This is considered to be a good support for the *S*-acetyl rather than the *N*-acetyl structure. These compounds are converted to the corresponding

Table IV

Infrared, Nuclear Magnetic Resonance and Electronic Spectral Data of Acetylpyrimidine Derivatives (VIa and c)

Compound No.	Infrared Spectra cm^{-1}	ν	Nmr Spectra (Deuteriochloroform) δ	Assignments (No. of Protons)	Electronic Spectra (Cyclohexane) λ max (nm)	λ max
VIa	1714 (s)	C=O	8.23-7.27 (m)	(10) Ar*H*	304	11,730
	1573 (s)	Pyrimidine	8.13 (s)	(1) -C*H*=	285-295 (sh)	13,920
	1515 (s)	ring	2.57 (s)	(3) $SCOCH_3$	260	35,400
VIc	1718 (s)	C=O	8.33-7.33 (m)	(9) Ar*H*	301-308 (sh)	13,630
	1578 (s)	Pyrimidine	7.82 (s)	(1) -C*H*=	287	15,810
	1518 (s)	ring	2.55 (s)	(3) $SCOCH_3$	260	37,250

Table V

The Electronic, Nuclear Magnetic Resonance and Infrared Spectral Data of 2,2̄-*bis*-(4,6-diarylpyrimidinyl) Disulfides (VIIa-f)

Compound No.	Electronic Spectra (Ethanol) λ max (nm)	ε max	Nmr Spectra (Deuteriochloroform) δ	Assignments (No. of Protons)	Infrared Spectra (Potassium bromide) cm^{-1}	ν
VIIa	320	21,800	7.37-8.23 (m)	(20) Ar*H*	1570 (s)	Pyrimidine
	263	53,440	7.83 (s)	(2) -C*H*=	1515 (s)	ring
VIIb	322	30,505	7.07-8.17 (m)	(18) Ar*H*	1555 (s)	Pyrimidine
	267	65,860	7.93 (s)	(2) -C*H*=	1490 (s)	ring
			2.33 (s)	(3) $ArCH_3$		
VIIc	321	17,015	7.4-8.27 (m)	(18) Ar*H*	1570 (s)	Pyrimidine
	262	45,200	7.87 (s)	(2) -C*H*=	1514 (s)	ring
VIId	323	28,635	7.47-8.30 (m)	Ar*H* + -C*H*=	1570 (s)	Pyrimidine
	268	72,150			1513 (s)	ring
VIIe	326	47,430	7.03-8.35 (m)	(18) Ar*H*	1608 (m)	C=C
	298-285 (sh)	49,870	8.02 (s)	(2) -C*H*=	1572 (s)	Pyrimidine
	264	60,630	3.95 (s)	(3) $ArOCH_3$	1520 (s)	ring
	232	44,790				
VIIf	338	27,120	6.73-8.23 (m)	(18) Ar*H* + -C*H*=	1575 (s)	Pyrimidine
	265	33,450	6.0 (s)	(4) OCH_2O	1510 (s)	ring
	241	37,970				

thiones (IV) when dissolved in hot ethanol.

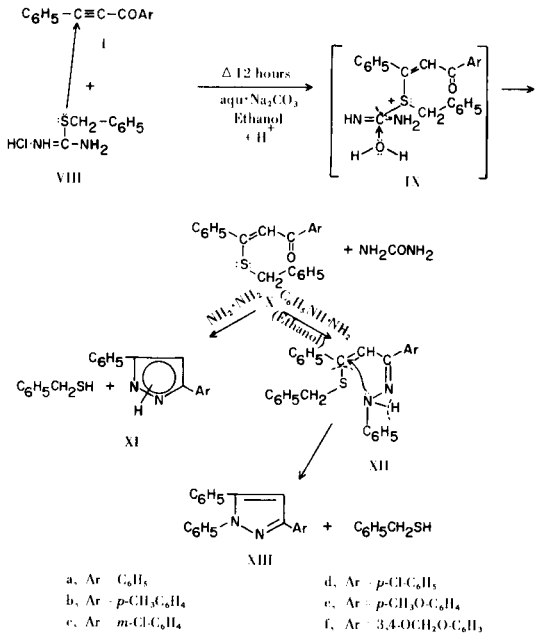
Oxidation of the thiones (IVa-f) with sodium hydrogen sulfate and sodium nitrite gave the corresponding 2,2-*bis*-(4,6-diarylpyrimidinyl) disulfide (VIIa-f) (2). The structure of the latter compounds was substantiated by their uv, ir and nmr spectra (*cf.* Table V). Their uv spectra give a strong evidence for the proposed structure, since most of them are very similar to those of the *S*-methyl derivatives (V) (*cf.* Table III) with nearly double the molar extinction coefficient. Furthermore, their ir spectra show the bands characteristic of the pyrimidine ring at 1575-1555 cm^{-1} and 1520-1490 cm^{-1} (3b) and their nmr spectra show signal corresponding to (-CH=) and aromatic protons.

Reaction of Acetylenic Ketones with *S*-Benzylisothiourea Hydrochloride.

When the acetylenic ketones (Ia-f) were refluxed with an alcoholic solution of *S*-benzylisothiourea hydrochloride containing the stoichiometric amount of aqueous sodium carbonate solution, they gave the corresponding α-aroyl-β-benzylmercaptostyrene (X) (*cf.* Scheme 2).

The structure of the products was established chemically and spectroscopically. Thus, compound (Xd) was identical with that obtained by the interaction between *p*-chlorobenzoylphenylacetylene (Id) and benzylthiol in the presence of an ethereal suspension of sodium ethoxide. These compounds (Xa-f) reacted with hydrazine hydrate to give the corresponding 5(3)aryl-3(5)phenylpyrazole (XIa-f) and benzylthiol. However, the reaction of Xd with phenylhydrazine gave 3-*p*-chlorophenyl-1,5-diphenylpyrazole

Scheme 2



(XIII), which is identical with an authentic sample prepared by reacting the dibromide of benzal-*p*-chloroacetophenone with phenylhydrazine in methanolic potassium hydroxide (6). This indicated that the reaction proceeds by the initial formation of a hydrazone (XIId), followed by cyclization with the elimination of benzylthiol (*cf.* Scheme 2).

Table VI

The Nuclear Magnetic Resonance, Electronic and Infrared Spectral Data of α-Aroyl-β-benzylmercaptostyrenes (Xa-f)

Compound No.	Nmr Spectra (Deuteriochloroform) δ	Assignments (No. of Protons)	Electronic Spectra (Ethanol) λ max (nm)	ε max	Infrared Spectra (Potassium bromide) cm^{-1}	ν
Xa	8.2-6.97 (m)	(16) ArH + -CH=	339	19,640	1630 (s)	C=O
	3.63 (s)	(2) SCH_2-	260	12,390	1597 (m)	C=C
					1530 (s)	C=C
Xb	8.17-6.97 (m)	(15) ArH + -CH=	337	20,450	1630 (s)	C=O
	3.65 (s)	(2) SCH_2-	267	13,305	1605 (s)	C=C
	2.37 (s)	(3) $ArCH_3$			1530 (s)	C=C
Xc	7.83-6.87 (m)	(15) ArH + -CH=	342	17,800	1635 (s)	C=O
	3.60 (s)	(2) SCH_2-	258	13,090	1533 (s)	C=C
Xd	8.23-7.0 (m)	(15) ArH + CH=	339	18,530	1632 (s)	C=O
	3.67 (s)	(2) SCH_2-	266	22,690	1591 (s)	C=O
					1533 (s)	C=O
Xe	8.03-6.77 (m)	(15) ArH + -CH=	339	25,830	1625 (s)	C=O
	3.60 (s)	(2) SCH_2-			1593 (s)	C=C
	3.78 (s)	(3) $ArOCH_3$	275-290 (sh)	10,050	1534 (s)	C=C
Xf	7.63-6.73 (m)	(14) ArH + -CH=	349	23,810	1625 (s)	C=O
	3.63 (s)	(2) SCH_2-			1597 (s)	C=C
	5.97 (s)	(2) OCH_2O	276	6,840	1535 (s)	C=C

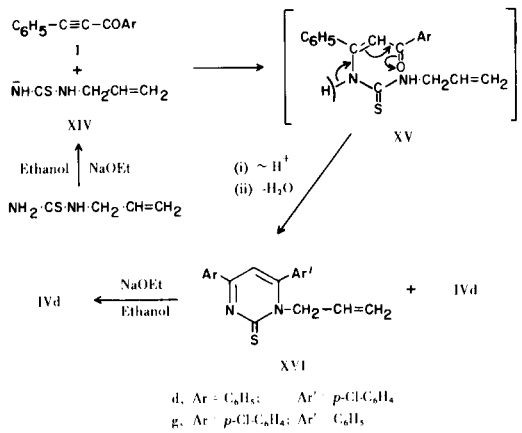
Spectral data (*cf.* Table VI) of these compounds (Xa-f) also give further support for the assigned structure. Thus, their nmr spectra show a singlet at δ 3.67-3.60 (2, s, SCH_2-) (7) in addition to the multiplet for the aromatic protons. Their ir spectra show a strong band at 1630-1625 cm^{-1} (ν C=O) (6). The uv spectra of these compounds show two bands in the regions 350-337 and 276-258 nm, which are due to $\pi \rightarrow \pi^*$ transition. Those of Xd and Xe show good resemblance to the spectra of the corresponding α-aroyl-β-methylmercaptostyrenes especially in the longer wavelength band (6). This is considered to be a good support for the proposed structure.

The formation of these compounds (Xa-f) cannot be attributed to the decomposition of *S*-benzylisothiourea (VIII) to benzylthiol prior to addition to the acetylenic ketones, since when the reagent VIII was heated with an aqueous alcoholic solution of sodium carbonate under the same condition it was recovered unchanged. It appears that the reaction proceeds by the mechanism outlined in Scheme 2, in which the attack of *S*-benzylisothiourea on the acetylenic ketone takes place by the sulfur atom rather than by the less nucleophilic NH_2 group to give the intermediate IX, which is hydrolyzed to give the product X and urea (formation of biuret).

Reaction of Acetylenic Ketones with *N*-Allylthiourea.

When benzoyl-*p*-chlorophenyl- (Id) and *p*-chlorobenzoylphenyl- (Ig) acetylenes were allowed to react with *N*-allylthiourea in the presence of sodium ethoxide in ethanol, they gave rise to the corresponding 1-allyl-4,6-diarylpyrimidine-2(1*H*)thiones (XVId,g). The former acetylenic ketone (Id) gave in addition a small amount of the thione IVd. Thione IVd appears to result from the decomposition of XVId, since the latter compound was found to decompose to give IVd by heating with an alcoholic solution of sodium ethoxide. The reaction seems to proceed by Michael addition of the anion XIV, to the

Scheme 3



d, Ar = C_6H_5; Ar' *p*-Cl-C_6H_4
g, Ar *p*-Cl-C_6H_4; Ar' C_6H_5

aroylphenylacetylene followed by cyclization of the intermediate XV (*cf.* Scheme 3). This mechanism is similar to that proposed for the reaction of thiourea with acetylenic ketones (2).

The structure of the 1-allylthiones (XVId,g) was established by spectroscopic evidence (*cf.* Table VII). Thus, their thione structure was substantiated by their electronic spectra in ethanol which show bands at 294 and 298 nm, respectively ($\pi \rightarrow \pi^*$ transition) as well as low intensity bands at 397 and 404 nm, respectively, which are red shifted in cyclohexane, indicating that they are due to $n \rightarrow \pi^*$ transition in the >C=S chromophore. Their nmr spectra show a multiplet signal at δ 5.33-4.6, attributable to (-CH_2-CH=CH_2 group) and a sharp singlet at δ 6.93 and 6.83 (-CH=), respectively. The higher δ value for the olefinic proton of XVId is due to the deshielding effect of the conjugated *p*-chlorophenyl substituent. The infrared spectra of these compounds show bands at 3080-3070 cm^{-1} (ν C-H in CH=CH_2) (3c), and 4 bands in the range 1600-1522 cm^{-1} (ν C=N and ν C=C in CH=CH_2 and aromatic rings) (3c).

Table VII

Electronic, Nuclear Magnetic Resonance and Infrared Spectral Data of 1-Allyl-4,6-diarylpyrimidine-2(1*H*)thiones (XVId,g)

Compound No.	Electronic Spectra (Ethanol) λ max (nm)	ε max	Nmr Spectra (Deuteriochloroform) δ	Assignment (No. of Protons)	Infrared Spectra (Potassium bromide) cm^{-1}	ν
XVId	397	4,000	8.27-7.27 (m)	(9) Ar*H*	3070 (m)	CH of CH=CH_2
	294	38,730	6.93 (s)	(1) -C*H*=	1610 (s)	CH=CH_2,
			5.33-4.67 (m)	(5) -CH_2-CH=CH_2	1591 (s)	C=N
					1582 (s)	and
					1525 (s)	C=C
XVIg	404	2,490	8.13-7.03 (m)	(9) Ar*H*	3080 (m)	C-H of CH=CH_2
	298	34,050	6.83 (s)	(1) -C*H*=	1610 (s)	CH=CH_2,
			5.27-4.6 (m)	(5) -CH_2-CH=CH_2	1590 (s)	C=N
	In Cyclohexane				1574 (s)	and
	435	2,020			1522 (s)	C=C
	294	32,470				

Table VIII

4,6-Diarylpyrimidine-2(1*H*)thiones (IVa-f)

Compound No.	Yield (%)	M.p., °C	Formula	Calcd. (%) C	H	N	S	Cl	Found (%) C	H	N	S	Cl
IVa	99	166-167 (a)	$C_{16}H_{12}N_2S$	72.69	4.48	10.60	12.15	--	73.05	4.14	10.48	11.74	--
IVb	91	145-146 (a)	$C_{17}H_{14}N_2S$	73.35	5.07	10.06	11.52	--	73.15	5.11	9.75	10.94	--
IVc	89	180-181 (a)	$C_{16}H_{11}ClN_2S$	64.32	3.71	9.38	10.73	11.87	63.98	3.66	9.08	10.61	11.55
IVd	97	180-181 (b)	$C_{16}H_{11}ClN_2S$	64.32	3.71	9.38	10.73	11.87	64.17	3.93	9.22	10.91	12.09
IVe (c)	95	165-166 (b)	$C_{17}H_{14}N_2OS$	69.36	4.79	9.52	10.89	--	62.26	4.79	9.56	10.98	--
IVf	92	195-196 (b)	$C_{17}H_{12}N_2O_2S$	66.22	3.92	9.08	10.40	--	66.31	3.89	9.29	10.24	--

(a) Crystallized from acetic acid. (b) Crystallized from benzene. (c) OCH_3%: Calcd. for = 10.54; Found = 10.73.

Table IX

4,6-Diaryl-2-methylmercaptopyrimidines (Va-f)

Compound No.	Yield (%)	M.p., °C	Formula	Calcd. (%) C	H	N	S	Cl	Found (%) C	H	N	S	Cl
Va	75	152-153	$C_{17}H_{14}N_2S$	73.35	5.07	10.06	11.52	--	73.44	5.02	10.07	11.56	--
Vb	80	90-91	$C_{18}H_{16}N_2S$	73.94	5.52	9.58	10.96	--	73.82	5.49	9.66	10.99	--
Vc	79	91-92	$C_{17}H_{13}ClN_2S$	65.27	4.19	8.96	10.25	11.34	64.99	4.22	8.86	10.31	11.56
Vd	77	140-141	$C_{17}H_{13}ClN_2S$	65.27	4.19	8.96	10.25	11.34	65.11	4.22	9.21	10.20	11.22
Ve	72	101-102	$C_{18}H_{16}N_2OS$	70.10	5.23	9.08	10.40	--	70.20	5.44	9.32	10.20	--
Vf	78	123-124	$C_{18}H_{14}N_2O_2S$	67.06	4.38	8.69	9.95	--	67.22	4.42	8.83	9.63	

Table X

2,2-*bis*-(4,6-Diarylpyrimidinyl) Disulfides (VIIa-f)

Compound No.	Yield (%)	M.p., °C	Formula	Calcd. (%) C	H	N	S	Cl	Found (%) C	H	N	S	Cl
VIIa	100	240-241 (a)	$C_{32}H_{22}N_4S_2$	72.98	4.21	10.64	12.18	--	72.87	4.19	10.46	12.21	--
VIIb	97	209-210 (b)	$C_{34}H_{26}N_4S_2$	73.62	4.73	10.10	11.56	--	73.77	4.78	10.44	11.33	--
VIIc	98	185-186 (b)	$C_{32}H_{20}Cl_2N_4S_2$	64.53	3.39	9.41	10.77	11.91	64.81	3.43	9.63	10.51	11.88
VIId	92	223-224 (c)	$C_{32}H_{20}Cl_2N_4S_2$	64.53	3.39	9.41	10.77	11.91	64.50	3.62	9.49	10.60	11.71
VIIe (d)	95	217-219 (b)	$C_{34}H_{26}N_4O_2S_2$	69.60	4.47	9.55	10.93	--	69.97	4.28	9.74	10.99	--
VIIf	95	217-218 (c)	$C_{34}H_{22}N_4O_4S_2$	66.44	3.61	9.12	10.43	--	66.22	3.52	9.21	10.33	--

(a) Crystallized from acetic acid. (b) Crystallized from benzene. (c) Crystallized from benzene-methanol. (d) OCH_3% Calcd.: 10.58. Found: 10.74.

EXPERIMENTAL

Ir spectra were recorded using a Pye-Unicam SP 1000 and Beckman IR 12 spectrophotometers (Potassium bromide). Nmr spectra were recorded on a Varian T-60 A Spectrometer using TMS as internal standard. Electronic spectra were recorded on a Pye-Unicam SP 8000 Spectrometer (ethanol). Melting points are uncorrected. The purity of the analytical samples was checked by tlc (Silica gel). Micro-analyses were determined by Alfred Bernhardt, West Germany.

4,6-Diarylpyrimidine-2(1*H*)thiones (IV).

An alcoholic solution of thiourea (0.0146 mole) in 10 ml. of ethanol was added to a solution of the acetylenic ketone (I) (8) (0.0146 mole) and sodium ethoxide (0.99 g.) in ethanol (50 ml.), and the mixture refluxed for 30 minutes. The solvent was removed under reduced pressure, the residue was dissolved in water (about 50 ml.), extracted with ether to remove the unreacted material, cooled and acidified with acetic acid (8 ml.). Crystallization of the crude products from suitable solvents gave 4,6-diarylpyrimidine-2(1*H*)thiones (IV) as yellow crystals. The results are reported in Table VIII.

4,6-Diaryl-2-methylmercaptopyrimidines (V).

i. Dimethyl sulfate (8 ml.), potassium carbonate anhydrous (16.0 g.) and the thione IV (1.0 g.) in dry acetone (50 ml.) was refluxed on a boiling water-bath for 12 hours and the reaction product worked up as usual to give the corresponding 4,6-diaryl-2-methylmercaptopyrimidines (V) as colorless crystals (from cyclohexane). The results are reported in Table IX.

ii. The thione IV (1.0 g.) in methanol (10 ml.) was treated with an ethereal solution of diazomethane [from nitrosomethylurea (3.0 g.)]. The reaction products (yield, 85-92%) were crystallized from cyclohexane to give the above products.

Oxidation of 4,6-Diarylpyrimidine-2(1*H*)thiones (IV) to 2,2̄-*bis*-(4,6-Diarylpyrimidinyl) Disulfides (VIIa-f).

The suspension of thione IV (1.0 g.) and sodium hydrogen sulfate (1.0 g.) in ethanol (15 ml.) was treated portion-wise with an aqueous solution of sodium nitrite (1.0 g., in 5 ml. of water). The mixture was heated on a boiling water-bath for 10 minutes, whereby a colorless solid precipitated out. The reaction mixture was diluted with water (20 ml.) and the precipitate filtered off. Crystallization of the crude products from suitable solvents gave the corresponding 2,2̄-*bis*-(4,6-diarylpyrimidinyl) disulfides (VII) as colorless crystals. The results are reported in Table X.

2-Acetylmercapto-4,6-diarylpyrimidines (VIa,c).

The thione IV (1.0 g.) was heated with acetic anhydride (3 ml.) on a boiling water-bath for 2 hours. The product, which precipitated on addition of cold 50% ethanol (15 ml.), was crystallized from cyclohexane to give the corresponding 2-acetylmercapto-4,6-diarylpyrimidine (VI) as colorless needles.

2-Acetylmercapto-4,6-diphenylpyrimidine (VIa).

This compound had m.p. 120-121°, yield = 95%.

Anal. Calcd. for $C_{18}H_{14}N_2OS$: C, 70.56; H, 4.61; N, 9.14; S, 10.46; $COCH_3$, 14.05; M.W., 306. Found: C, 70.71; H, 4.59; N, 9.36; S, 10.09; $COCH_3$, 14.24; M.W. (MS), 306.

2-Acetylmercapto-6-*m*-chlorophenyl-4-phenylpyrimidine (VIc).

This compound had m.p. 130-131°, yield = 92%.

Anal. Calcd. for $C_{18}H_{13}ClN_2OS$: C, 63.43; H, 3.84; N, 8.22; Cl, 10.40; S, 9.41. Found: C, 63.22; H, 3.71; N, 8.32; Cl, 10.13; S, 9.19.

When the above compounds VI were warmed in ethanol for 2 minutes, they decomposed to the corresponding 4,6-diarylpyrimidine-2(1*H*)thiones (IV), identified by m.p. and mixed m.p.

Reaction of Aroylphenylacetylenes (Ia-f) with *S*-Benzylisothiourea Hydrochloride.

A refluxing solution of a mixture of the aroylphenylacetylene (0.05 mole) and *S*-benzylisothiourea hydrochloride (10.14 g.) in ethanol (50 ml.) was treated portionwise during 2 hours with aqueous sodium carbonate (2.65 g., in 10 ml. of water). Refluxing was continued for a further 10 hours, and the reaction mixture was diluted with water (100 ml.) and extracted with benzene. The products were crystallized from suitable solvents to give the corresponding α-aroyl-β-benzylmercaptostyrenes (X) as pale yellow crystals (from cyclohexane). The results are reported in Table XI. The presence of urea in the mother liquor was established by evaporation under reduced pressure. The residue was heated (ammonia evolved), then dissolved in 10% sodium hydroxide solution and treated with very diluted copper sulfate solution. A purple coloration was obtained (formation of biuret) (9).

β-Benzylmercapto-α-(*p*-chlorobenzoyl)styrene (Xd) was also obtained by stirring a solution of benzylthiol (1.55 g.) in dry ether (50 ml.) with molecular sodium (0.3 g.) at room temperature for 5 hours, then treating the reaction mixture with a solution of *p*-chlorobenzoylphenylacetylene (Id) (3.0 g.) in ether (50 ml.) and the mixture was stirred for further 12 hours. The reaction product was poured into water (200 ml.), and the ether layer was washed with water and dried (sodium sulfate). The product was crystallized from cyclohexane to give β-benzylmercapto-α-(*p*-chlorobenzoyl)-styrene (Xd) as pale yellow crystals (yield = 85%), m.p. and mixed m.p. 105-106°.

Reaction of α-Aroyl-β-benzylmercaptostyrenes (Xa-f) with Hydrazine Hydrate.

Hydrazine hydrate (99% w/w: 5 ml.) was added to the mercaptostyrene derivatives (X) (2 g.), and the mixture refluxed for 30 minutes. The reaction products were diluted with water and the

Table XI

α-Aroyl-β-benzylmercaptostyrenes (Xa-f)

Compound No.	Yield (%)	M.p., °C	Formula	Calcd. (%) C	H	S	Cl	OCH_3	Found (%) C	H	S	Cl	OCH_3
Xa	93	139-140	$C_{22}H_{18}OS$	79.97	5.49	9.70	--	--	80.17	5.50	9.60	--	--
Xb	95	93-94	$C_{23}H_{20}OS$	80.20	5.85	9.31	--	--	80.32	5.92	9.52	--	--
Xc	87	99-100	$C_{22}H_{17}ClOS$	72.42	4.70	8.79	9.72	--	72.55	4.81	8.77	9.98	--
Xd	89	105-106	$C_{22}H_{17}ClOS$	72.42	4.70	8.79	9.72	--	72.11	4.86	8.73	9.88	--
Xe	90	101-102	$C_{23}H_{20}O_2S$	76.64	5.59	8.89	--	8.61	76.61	5.45	8.87	--	8.88
Xf	92	138-139	$C_{23}H_{18}O_3S$	73.76	4.85	8.56	--	--	74.01	4.91	8.42	--	--

precipitated solids were filtered off and crystallized from ethanol to give the corresponding 5(3)-aryl-3(5)-phenylpyrazoles (XI) as colorless needles, yield = 82-82%, identified by m.p. and mixed m.p. (2), and ir spectra.

The aqueous layer was extracted with ether, and the extract proved to be benzylthiol.

Reaction of β-Benzylmercapto-α-(*p*-chlorobenzoyl)styrene (Xd) with Phenylhydrazine.

Phenylhydrazine (2.0 ml.) was refluxed for 3 hours with a solution of β-benzylmercapto-α-(*p*-chlorobenzoyl)styrene (Xd) in ethanol (20 ml.). The yellow oil obtained on concentration was triturated with methanol to give 3-(*p*-chlorophenyl)-1,5-diphenylpyrazole (XIId) as colorless needles (yield = 96%), identified by m.p. and mixed m.p. (135-136°) with an authentic sample, prepared by the reaction of the dibromide of benzal-*p*-chloroacetophenone with phenylhydrazine (6).

The methanol mother liquor was evaporated and the residue extracted with ether. The ethereal layer was washed with dilute hydrochloric acid and evaporated to give benzylthiol.

1-Allyl-4,6-diarylpyrimidine-2(1*H*)thiones (XVId and g).

An alcoholic solution of *N*-allylthiourea (1.70 g.) in 10 ml. of ethanol was added to a solution of the acetylenic ketone (0.0146 mole) and sodium ethoxide (0.99 g.) in ethanol (50 ml.), and the mixture refluxed for 30 minutes. The solvent was removed under reduced pressure, the residue was diluted with water and extracted with ether. Evaporation of the solvent left orange solids which were crystallized from ethanol to give 1-allyl-4,6-diarylpyrimidine-2(1*H*)thiones (XVId and g) as orange needles.

Acidification of the alkaline aqueous layer with acetic acid (5 ml.) gave a yellow solid, which on crystallization from benzene gave the pyrimidine thione (IVd) in 5-8% yield, m.p. and mixed m.p. 180-181°.

1-Allyl-6-(*p*-chlorophenyl)-4-phenylpyrimidine-2(1*H*)thione (XVId).

This compound had m.p. 195-196°, yield = 55%.

Anal. Calcd. for $C_{19}H_{15}ClN_2S$: C, 67.35; H, 4.46; N, 8.27; S, 9.46; Cl, 10.46. Found: C, 67.43; H, 4.35; N, 8.11; S, 8.95; Cl, 10.20.

1-Allyl-4-(*p*-chlorophenyl)-6-phenylpyrimidine-2(1*H*)thione (XVIg).

This compound had m.p. 167-168°, yield = 52%.

Anal. Calcd. for $C_{19}H_{15}ClN_2S$: C, 67.35; H, 4.46; N, 8.27; S, 9.46; Cl, 10.46. Found: C, 67.31; H, 4.42; N, 8.34; S, 9.35; Cl, 10.56.

Heating of an alcoholic solution of the allylpyrimidine derivative XVId or XVIg [1.0 g., in absolute ethanol (25 ml.)] in the presence of sodium ethoxide (0.2 g.) for 30 minutes on a boiling water bath, gave after acidification, 4(6)-(*p*-chlorophenyl)-6(4)-phenylpyrimidine-2(1*H*)thione (IVd), m.p. and mixed m.p. 180-181°.

REFERENCES AND NOTES

(1) Part IV, N. R. El-Rayyes and F. H. Al-Hajjar, *J. Heterocyclic Chem.*, **14**, 367 (1977).

(2) F. G. Baddar, F. H. Al-Hajjar and N. R. El-Rayyes, *ibid.*, **13**, 257 (1976).

(3) L. J. Bellamy, "The Infrared Spectra of Complex Molecules", Methuen, London, 1966, pp. (a) 263, (b) 283, (c) 34.

(4) A. Sammour, M. I. B. Selim, M. M. Nour El-Deen and M. Abd-El-Halim, *U. A. R., J. Chem.*, **13**, 7 (1970).

(5) L. J. Bellamy, "Advances in Infrared Group Frequencies", Volume 2, "Infrared Spectra of Complex Molecules", Methuen, London, 1975, p. 171.

(6) F. G. Baddar, F. H. Al-Hajjar and N. R. El-Rayyes, *J. Heterocyclic Chem.*, **13**, 691 (1976).

(7) R. M. Silverstein, G. C. Bassler and T. C. Morrill, "Spectrometric Identification of Organic Compounds", John Wiley and Sons, London, 1974, p. 221.

(8) F. G. Baddar, F. H. Al-Hajjar and N. R. El-Rayyes, *J. Heterocyclic Chem.*, **13**, 195 (1976).

(9) F. G. Mann and B. C. Saunders, "Practical Organic Chemistry", Longman, London, 1971, p. 360.